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Discussion of all papers is invited

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PUBLICITY OF THE RIGHT KIND FOR WATER WORKS PROPERTIES[1]

BY DOW R. GWINN[2]

One can imagine a utility operator saying that he was getting too much publicity. He refers to the wrong kind of publicity. A utility cannot get too much publicity of the right kind, that is, good publicity.

Some operators take their publicity matter to the editor, when they should see the advertising manager. They fail to distinguish the difference between news matter and that which belongs in the advertising columns. An operator who would resent the suggestion that he furnish service free of charge, should keep that idea in mind when he goes to the newspaper office with copy. A newspaper must charge for advertising matter. Therefore, when you wish to acquaint the public with facts about the water works business, see the advertising manager and make a contract for space.

The average water works operator is better qualified to prepare copy about his business than the average advertising solicitor. Plenty of time should be taken in the preparation of copy. If a series of advertisements are to be used, it is advisable to start in with one of a historical character, a second with some of the difficulties of a practical character that had to be overcome; the third

[1] Presented before the Iowa Section meeting, November, 2, 1922.

[2] President and Manager, The Terre Haute Water Co., Terre Haute, Ind.

insertion could give a description of the present system, why it was used. Somewhere through the series, the name of the engineer or engineers should be given, the trouble in financing the enterprise, the names of those who bore the responsibility of getting the works started. Credit should be given where due. It is a mistake to try to tell too much in one issue of the paper. In most cases, 5 inches, three columns wide is sufficient space, with at least two insertions of each story or talk. Change copy weekly. Contract for space on the editorial page if it is used for advertisements. It is advisable to complete copy for the entire series before beginning publication.

The average man in the street and the woman in the home do not know of the diffculties which must be overcome in securing and maintaining a good water supply. The relations with the public may be improved by informing the public about the water business, provided, of course, the water supply is good and the service satisfactory. The first essential in good publicity is good water, including satisfactory pressure, coupled with courteous treatment.

The public should be taken into the confidence of the water works operator; it is poor policy for the public to get the idea that the operator is covering up something. Let the public know what you are doing. If you contemplate important improvements, take space in the newspaper and state what you are about to do, whom you have engaged to plan the work, the standing of the engineer and what he has done in other cities. If an application is to be made for an increase in rates, space should be bought for making the announcement and full particulars should be given so that the public will be able to judge as to the reasonableness of the claim for higher rates.

In furnishing information to the public, it is well to bear in mind that the majority of people are honest and fair and are willing to pay a reasonable price for good water service when they are convinced that the price is reasonable; that the utility is making only a moderate profit.

Pease note that reference is made to *good water service.* All that has been stated in the foregoing and all that follows is based on "*good water service.*" In this day and generation, there should be only one kind of water supplied to the public—good, wholesome, sanitary, unpolluted, safe water—the kind that the operator is willing to give his child or members of his family.

In the matter of a public water supply, the first, the fundamental, the essential and most important point is to have water of unques-

tioned purity. It should be like Caesar's wife, above suspicion. There is not much use in considering publicity of a water supply until its purity is of a high standard. Along with pure water, good pressure and courteous treatment should be closely associated. Courtesy and politeness are so inexpensive and bring such large returns that they should be constantly in evidence.

After or during the publication of series of advertisements (call them "water talks" if you please), an effort should be made to get the public to visit the pumping station and other portions of the plant. Incidentally, the grounds around the station should be made attractive and pleasing. At Terre Haute, we had a landscape gardener make a plan for us, but usually the nurseryman can give excellent ideas on planting shrubbery and trees. First, we set out Boston ivy which now covers most of the outside walls. Shrubbery, such as Spirea and Barberry, were set close to the walls so as to cover the break between the foundation and ground. Trees and shrubs were planted on the outside lines of the grounds, leaving a grass plot for the center—a vista, I believe, it is called. Our grounds are so arranged that the view of the river from one point is the center of the picture with a green frame on either side. Such grounds are desirable for picnics and we invite the public to use them. So much of a water works plant is below the surface of the ground—out of sight—that it is desirable to have the visible portions as attractive as possible.

During the past summer, the Rotarians, the Kiwanis Club and the Exchange Club served noon day luncheons on our grounds; the Lions and their wives served supper. We have tables (trestles and boards) sufficient for 140 people; our men set the tables, cover them with white paper (it comes in rolls), put on the glasses, forks and spoons. The caterer who is engaged and paid by the Club, furnishes the food, plates and paper napkins. We furnish the water, coffee and, sometimes, small bottles of milk. In this way, the live wires of the City, the men who are doing things, visit our plant, see what we have and, judging by many comments, go away with a good impression of the local water works plant. We help serve by seeing that there is plenty of ice water for the thirsty. Of course, the newspaper men are present and the luncheons are duly written up with usually some reference to the water works. It is always favorable publicity.

Some years ago, we invited, at different times, the Medical Society, the Young Business Men's Club and the Manufacturers Club, etc. to visit our plant and we served the lunch. It gave us an opportunity of explaining the scientific methods of water purification in use at our plant.

We have an unusually fine tennis court which may be reserved by the public by telephone, no charge being made. The finals of tennis tournaments are played on the Water Works court. The court attracts people to our plant.

Once a year, we give a picnic to our employees and their families. The last two years, the picnic has been preceded by a boat ride of a couple of hours on the Wabash. The lunch is served on the grounds at our Station on the return of the boat. These are happy occasions and are looked forward to by most of our people. Photographs are made and each family is furnished with one and, in many cases, they are framed. It is customary for the newspapers to devote considerable space to the picnic and the photographs are reproduced in a subsequent issue. This is fine publicity as it shows the relations between the employees and the Company.

Several years ago, we bought over three thousand $\frac{5}{8}$ inch meters that come five in a box. The boxes were made of planed pine wood and were about the right size for flowers for a window or porch. It was announced in the newspapers that 600 flower boxes would be given away at the Water Office at 9:00 a.m. on a certain day to those holding coupons which were printed with the notice. The crowd that appeared almost blocked the street traffic and in twenty minutes the last box had been given away. Photographs were taken of the crowd and the cuts duly appeared in the press in addition to complimentary reading notices. This was fine publicity at a small cost.

The record of fatal typhoid cases in Terre Haute since 1909 has dropped from 60 to 5 per one hundred thousand population. In the same period, the number of water consumers has increased from about 5200 to about 9000. A drawing, $8\frac{1}{2}$ by 11 inches, was made showing these facts graphically, with a note calling attention to the relation between the number of City water consumers and the number of fatal typhoid cases. The two curves make a fine showing. For three years, we have prepared these drawings and have made about 400 blueprints from the tracings. These, with a multigraph letter with typewritten addresses, have been mailed to a selected list of names. The list includes the State Health Officials, members

of the Public Utility Commission, local officials, physicians, nurses, college and school principals, and all members of the Rotary Club. One of the letters was as follows:

With the idea that you are interested in all the good things that Terre Haute enjoys, we are enclosing a blue print showing the local typhoid record for a period of eleven years including 1920. It is interesting to note that as the number of our patrons has increased, the typhoid deaths have decreased.

Incidentally, we are striving to make the public water service of Terre Haute as near perfection as possible. We have an organization of trained men to watch over and guard your water supply; one of our faithful helpers has been employed at the pumping station for over thirty years. We have several men who have been with the Company for a quarter of a century. Our Chief Engineer and Chemist has been in the Water Business over 35 years.

An electric program clock calls the attendants every thirty (30) minutes to examine the water. Some half dozen tests of the filtered water are made every day in our laboratory. Reports are made weekly to the State Board of Health, and inspection visits are made from time to time, without notice, by officers of that Board. Your water supply meets the severe and strict requirements of the U. S. Public Health Service.

When you have visitors from out of the City, tell them about Terre Haute's good water.

Bring your picnic supper down to our park; make up a party and enjoy the view of the river and sunset. If you will telephone before starting, we will arrange to have tables for you sufficient to accomodate two and up to fifty. Our tennis court may be reserved by calling Telephone 213 on the day before it is desired. It is advisable to call early, as the court is in demand.

Yours for Good Water Service,

P. S. In summing up the good things of Terre Haute, keep in mind the unusually fine educational advantages.

The writer is of the opinion that the best form of advertising is through the public press, but there are occasions when a personal letter, multigraphed with typewritten address, is effective. A sample letter follows:

There are times in every business of any magnitude that problems arise in connection with the water supply, such as arrangement and size of pipes, boiler incrustation, and the most economical method of using water.

Our object in writing at this time is to suggest that we will be glad to assist our valued customers (and also our fellow citizens who may not be customers) in so far as our knowledge and experience can help in solving such problems as may arise in connection with water supply. We maintain a well equipped Laboratory.

Our Mr. Durbin, Vice President and Assistant Manager, is a Civil Engineer and Chemist, a graduate of Ohio State University, and has had extended

experience in the purification and distribution of water supply; he was also connected with the U. S. Housing Corporation, in the work of laying out residence sections so as to combine beauty, utility and convenience.

Our Mr. Taylor, Chief Engineer, Chemist and Bacteriologist, has been engaged in the water supply business for over a third of a century; his practical experience makes him a valuable man as advisor and counselor. Miss Kathryne Kintz, Chemist, is Mr. Taylor's Assistant.

Our Mr. Ranbarger has been with this Company for 29 years; he is a thoroughly practical man in the matter of pumps, boilers and accessory equipment.

Our Mr. Johnson has been in the Water Supply business for 20 years and is particularly conversant with the laying out and arrangement of supply pipes.

We have a strong organization of practical men who have made the good water service of Terre Haute a reality—a splendid asset of the City. These men are available in helping you with any water supply problem that may arise. Unless there should be a very rare case requiring extended study, and an unusual amount of time, there will be no charge for the service rendered. We want our fellow citizens, neighbors and friends to have the benefit of the services of this organization.

We also sent a special letter to real estate men advising that the price of cast iron pipe was extremely high; that money was dear and hard to get and that a survey showed over 2500 vacant lots on the lines of existing water mains. We enclosed extract from Mr. Brigham's article in the March, 1921, Atlantic Monthly to the effect that the United States Housing Corporation could have built houses where utilities were already installed much more quickly and cheaply; that the cost of improved vacant lots in the City was less than the improved acreage *plus the great cost of utilities*. Blueprints, showing the number of vacant lots on various streets, and blueprints of water mains were furnished real estate men.

After the great war was over, when cost of operation was still advancing and taxes had reached a high altidude, the Terre Haute Company found it was absolutely necessary to have another increase in rates. A series of articles was used in all the newspapers. Copies of the petition for an increase in rates and a valuation of our property were delivered to City officials and all newspapers. Notices of the hearing were published and the matter was presented at a meeting of the directors of the Chamber of Commerce. At the meeting, a resolution was unanimously passed recommending that our petition for an increase of rates be granted. The hearing was held in Indianapolis; the Secretary and two directors of the Chamber of Commerce were present and recommended the granting of our request. The Commission issued the order two days later,

giving us what we asked for. Later, after an appraisal by the State Engineers, the valuation was increased from about $1,300,000 to $1,800,000.

While our petition was pending, the Terre Haute Tribune printed an editorial and the following are extracts therefrom:

If the Water Company does not get an increase in rates, it cannot pay the tax increase. Rates are its only source of income. . . . . For six or seven years, dividends have been passed on the common stock for the purpose of keeping up the Terre Haute Water Plant to a necessary standard of efficiency. If this condition prevailed generally in public utility circles, we would have no public utilities.

On the same day, an editorial appeared in the Terre Haute Post addressed to the writer, as follows:

Your advertisement that you will apply for an increase in water rates because taxes on the properties of the water company have been increased $30,000 a year has our attention. The fact that you are taxed for more than your property has been valued at by the public service commission gives you the right to ask for higher rates. And to be called on for $30,000 more in taxes needs to make one look about for more income.

There will in all probability be no complaint or protest, for your company has been so fair and courteous that the folks here readily take your word. Moreover, the water service is the cheapest thing we have today. What householder would carry his water even from his own yard into his house for five times the price you ask for delivering it. Other utilities have elevated their prices far beyond your own, so we think you have just cause for some addition.

It is with some hesitancy that two other editorials are given in this paper. However, the title is "Publicity of the Right Kind," etc. so the editorials are included to show the result of a long continued policy of publicity in dealing with the public; of keeping faith with the public and furnishing good water, good service, and courteous treatment.

We Appreciate

Once in a while a corporation shows that it has the welfare of the community in which it operates at heart.

The Terre Haute Water Co. is demonstrating this. The fine spirit of coöperation which Manager Dow Gwinn is manifesting leads those who come into contact with his company to believe that not all public service concerns are heartless and inconsiderate.

If your water bill runs unusually high, Manager Gwinn calls your attention to it and wants to send down an inspector.

If there are too many fires and a consequent waste of much water, Mr. Gwinn wants to abolish the cause of the fires.

If you have a complaint it is courteously heard and then you are given relief. This spirit makes the water company an appreciated public utility.

HEAR YE, HEAR YE!

The quality of mercy is not strained. Most men will concur in the bard's observation when they know that Mr. Gwinn, head of our water works, last night advised the school board that the company had suggested that the city total up all of the school water meter readings each month and then the company would allow the city the lowest rate provided for such maximum consumption.

Republics may be ungrateful, but the popular fallacy that corporations have no souls is by this incident wholly and completely established. Corporations do not usually do business in this wise, at least they have such a reputation, and to see an actual demonstration of commercial philanthropy warms the cockles of the heart.

However, there is this about it. In this case the corporation likely imbides some of the mellow and beneficent nature of its chief director. No corporation no matter how soulless, no matter how hard-boiled, could long remain grim-visaged under daily contact with Dow R. Gwinn. If it was entirely soulless, he would see that such a void would be promptly eliminated. And no corporation would lose its soul, either, as long as this sentinel stood watch.

The Terre Haute city water supply is on the high efficiency plane required by the U. S. Public Health Service in connection with water used by inter-state carriers. The U. S. usually fixes a pretty high standard; however, when it comes to water service, the public is entitled to the very best. No ordinary, slip-shod, hit-or-miss, come-or-go, run-or-stop water service is good enough for the public. To make a hit with the public, the utility must furnish excellent, high-grade, A-1, double extra, superfine service.

When the service is good, take time to let the public know what you are doing; do not fail to let it be known that the water service is excellent. Candles were not made to be lighted and then covered with a bushel measure, but to be set where the light will show. Publish all the good things you can about the water serivce you are furnishing. Let the public know something about the difficulties you must overcome in order to maintain high-grade service. The best way to tell it is not from the house tops, but through the advertising columns of the local press. Advertising space in the local press is valuable and should be used to inform the public about your business.

DISCUSSION

MR. LEWIS I. BIRDSALL:[3] The speaker has listened with much interest to this splendid paper by Mr. Gwinn. We always expect some practical ideas to emanate from the Dean of Waterworks men, and again we have not been disappointed. All that Mr. Gwinn has said relative to the value of proper publicity for a privately owned water company is equally applicable to a municipally owned plant; in fact, municipally owned plants can well imitate to advantage many of the methods that are used by their privately owned relatives.

The Water Department of the City of Minneapolis has, during the past ten years, endeavored to educate the citizens to an appreciation of a pure water supply. When the Purification Plant was first put into service in 1913, there was almost universal suspicion of the quality of the city water. Gradually the people were induced to visit the plant, where they were courteously received and were conducted through the plant by one of the employees who was designated to serve as guide. Classes from the high schools, the State University, the grade schools of the city and from private institutions were encouraged to come regularly each year, until now the trip to the filtration plant is actually a part of the curriculum. Illustrated talks were given before various technical and other organizations, and an opportunity was always given for the asking of questions. On several occasions organizations such as the Rotary Club and the Real Estate Board had luncheon served at the plant. After the luncheon a brief talk descriptive of the plant was made, and the visitors were then shown through the plant in small groups, so that they might easily ask questions. An illustrated pamphlet descriptive of the entire water works system was printed and a copy given to each visitor at the plant. All technical language was avoided so as to make the reading matter intelligible to all. This pamphlet was used as a text in the schools.

The result of this publicity work at Minneapolis has been that thousands of citizens each year now visit the Water Purification Plant, many of them repeating the trip in order to take their friends along. They no longer consider the water supply unsafe, but instead they boast of their water supply as being one of the best in the whole United States. There has been an entire change in mental attitude through a proper use of publicity.

[3] General Chemical Company, Chicago, Ill.

Mr. Homer V. Knouse:[4] The problem of which Mr. Gwinn so ably speaks is of the greatest importance to water works managers, and all that he has said applies quite as much to the municipally owned plant as to properties that are privately owned. One point which was mentioned in the paper, but which was given slight emphasis, was that of courteous treatment. Publicity of the right sort will be quite without effect if there is a lack of courtesy to the public on the part of the water department employee, and no doubt Mr. Gwinn has long since instilled in his employees an attitude of careful consideration of the consumer's viewpoint, and his representatives explain in a kindly spirit the company's requirements. In fact, I believe it has been this application of the Golden Rule on the part of the President of the Company and of every employee, that has called forth such expressions of esteem in the editorial columns of the newspapers, and which has made the public able to grasp the viewpoint of the Company quite as much as the publicity campaign.

It is not often that such happy results are so emphatically brought out, but ample proof of the wisdom of the course of the Terre Haute Water Company may be found by considering the history of works where courtesy to the public has not been required on the part of the management or employee. In a plant, with which I am familiar, it seemed that discourtesy was encouraged, with the result that when purchase was proposed by the municipality the company found such feeling of distrust, and even of hatred, that years of litigation resulted. Legal expense and costly valuations absorbed what might have been net earnings, and, although large sums were then expended for publicity, it was without effect on minds which had been rendered immune to conciliatory statements on the part of the water company.

No problem that the water works executive is called upon to meet is of greater importance than that of cordial relations between public and utility, and every employee, from meter reader to president, must have a spirit of sincere interest in the success of the plant and be educated to meet tactfully the public as a necessary prelude to a publicity campaign.

Mr. J. Chris Jensen:[5] I do not feel that I can permit this discussion to be closed without adding that I feel there are still a great

[4] Metropolitan Water District, Omaha, Neb.

[5] Council Bluffs, Ia.

many water works managers and superintendents, particularly of privately owned plants, who have not yet discovered the value of the right kind of publicity, or the value of taking the community in which they operate into their confidence.

We still see many "Keep Out" signs on the doors of water works plants, which should be changed to read "Everybody Welcome!" I was talking to the head of a water works plant not very far from here a few days ago. The manager of this plant has had several years of controversy with the city in which the plant is located. The water plant needs higher water rates and the city needs many improvements and extensions to the plant. I asked this manager how he was getting along with his differences with the city. He said, "Oh, I have got the City out on a limb now, and if they are not good to me, I will just saw the limb off." I do not know just what he meant, but I think it is safe to say that he has not been giving his plant the right kind of publicity, or it would not be necessary for him to saw off the limb.

Mr. C. R. Henderson:[8] Mr. Gwinn omitted one item from his paper that I think is most important. When Mr. Gwinn went to Terre Haute, and for some time afterward, the City Administration, the Press and the Public appeared to be more or less unfriendly to the Water Company. It seemed to be the popular thing to criticize the action of the Company. It was not that the service was bad or that the employees were discourteous or that the charges for service were exorbitant. It seemed to be taken for granted that the Water Company was wrong. Let the company make a rule, the reaction of the public was that the rule was wrong, as a matter of course. The only thing that *was* wrong was that there was the lack of understanding on the part of the public as to what the company was doing to serve and as to the attitude of the utility toward its public.

Mr. Gwinn has brought about a reversal of public opinion in Terre Haute. The press writes in complimentary terms, instead of in terms of destructive criticism. The people generally know and believe that they are well served and that no advantage is being taken by the water utility.

In his paper Mr. Gwinn had given us facts and not theories. He has actually done the things he has told us about and he has accom-

[8] Davenport, Ia.

plished what he set out to do by advertising. He has shown us that all any water works man has to do to gain public approval is to give service and show courtesy and then tell the world what he is doing. By publicity and the winning over of public opinion to his side, Mr. Gwinn has been able to improve the service and the public has been better served than it would have been otherwise.

I think that the Iowa Section is very much indebted to Mr. Gwinn for coming here from Indiana with his interesting and valuable paper and I move a vote of thanks be extended to him.

Mr. George T. Prince:[7] The speaker is very much interested in the paper just read by Mr. Gwinn, and is in hearty accord with the views expressed by him as to the advisability of publicity of the right kind relative to the management of public water supplies.

When connected, as chief engineer, with the Denver Union Water Company at Denver, Colorado, that company instituted a publicity department, and in that connection engaged men expert in such matters. Many bulletins were prepared and submitted to the citizens of Denver whereby they would become thoroughly informed regarding the extent and character of the water supply system of the city, and giving such further information that would make plain to the ordinary layman the difficulties encountered and the methods adopted to safeguard the interests of the citizens, whereby the water supply would be in every particular satisfactory and the public health protected.

When acting as chief engineer of the Omaha Water Department, the same plan was adopted by the City, after purchasing this property. Bulletins were issued from time to time, placing before the citizens of the Metropolitan Water District, furnished by the department, information in considerable detail, descriptive of the property in all its branches, together with financial statements relative to operating costs. All of which was set forth in such plain manner as to be intelligible to the water takers.

Mr. Gwinn has referred to the fact that, as most of the property of a water department is underground and out of sight, it becomes more imperative that that portion of the property available for inspection should be made as attractive and pleasing in appearance as practicable. The power plant should be kept neat and clean; all brasswork

[7] Omaha, Neb.

and machinery constantly gone over and polished. The attendants should exert themselves courteously to inform visitors regarding the public water supply from the intake, where the raw water is obtained, to its final distribution to the properties served. Such information is of much interest to the public and serves to gain for the company or department furnishing water, the confidence which it should aim to have.

The grounds about the various engineering structures should be beautified by shrubbery, plants, fountains and other attractions, wherever practicable, all of which has been emphasized by Mr. Gwinn and will serve to express the desire which inspires every well ordered management to serve a pure water supply under the best possible conditions.

Mr. Gwinn is to be congratulated upon the great success he has accomplished at Terre Haute, which has a nation wide reputation for enjoying a pure and wholesome water supply that is not only satisfactory to those served, but, at the same time, the company enjoys an added confidence of the citizens of Terre Haute because of the physical attractions which his company has provided for their enjoyment and comfort.

It would be well for all water companies and water departments to profit by the methods and recommendations contained in the paper of Mr. Gwinn, to the end that the public may be inspired by absolute confidence in the management of its water department.

Mr. D. R. Gwinn:[2] Before this discussion is closed, I wish to thank the gentlemen who have expressed their views on publicity and also to say a few words.

In my opinion, the water works man should take part in the civic life of his community; he should not only be a member of the local Chamber of Commerce, but a working member, helping in every good work that will advance his Home City as a desirable place in which to live. Our Company pays for memberships of fifteen of our officials and workers in the Chamber of Commerce; they are full members with voting and other privileges.

Our Mr. Durbin is a member of the Rotarians and has been a director and official of that live organization. Our Secretary, Mr. Mandeville, is a member of the Lions.

May I also suggest that a Water Works man should be a member of some Church? Our civilization depends on the Churches and no

respectable citizen would want to live in a City where there were no Churches.

If a man prefers the Methodist, or Baptist, or Presbyterian Church, let him be a regular attendant and do his part towards supporting the Church he likes best. If he is a Catholic, let him be a good one. If a Jew, he should do his part in supporting and maintaining the Temple.

Be an important part in the community where you are living and to which you are furnishing water service. Follow the example of our good friend, Charlie Henderson, who is giving his spare time to making Davenport a good city to live in and in which to rear children.

Get acquainted with your neighbor—you might like him if you knew him. Let your attitude toward all men be of a friendly character; we are all children of one Father. Automobiles and yachts do not bring happiness, for happiness does not depend upon material possessions—it is spiritual. It is recorded in the Bible that Solomon said, "As a man thinketh in his heart, so is he."

In the fifth chapter of Matthew, sixteenth verse, you will find good advice on publicity of the right kind—it is this: "Let your light so shine before men that they may see your good works and glorify your Father which is in Heaven."

PRESIDENTIAL ADDRESS[1]

By W. S. Cramer[2]

The rule that applies in this Association, by which the President makes his address at the close of his administration, is favorable in that it permits the making of excuses rather than promises. It allows him also the pleasant privilege of giving advice to his successor.

There is no Association that covers such a wide field of operation as does this Association. It is rather a broad stretch from "Microforces, with Reference to Orientation and Curvature" to the question of "Packing and Lubrication of Fire Hydrants and Valves." Yet both of these subjects will be satisfactorily taken care of during this meeting.

A great deal of thought has been given to the every day problems of the operator of the smaller plants and the Committee who have this portion of the program in charge have given us two days filled with live topics and questions. We hope that their labors will be rewarded by hearty appreciation of the members to be evidenced by their participation in the discussion of these questions.

One lesson learned during the year is that the future growth of the Association will come through the Sections now functioning and those to be formed. It is hard to reach the individual through the mail and personal contact through local Sections is much more effective. This makes for team work which is necessary to keep the Association in its proper place as the leading national association of all groups of water works men.

The Sections have adopted the plan of meeting in a different city each year and this feature is enlarging the field of endeavor.

The monthly meetings of the New York Section held in the cities up state have been well attended and have increased the interest in the Association.

Several meetings of the Sections were attended by the Secretary and the President during the past year and it would be advisable to

[1] Presented before the Detroit Convention, May 22, 1923.

[2] Retiring President, American Water Works Association; Superintendent, Lexington Water Works, Lexington, Ky.

have the Officers of the Association arrange to have one of their number at each Section meeting. They will receive a hearty welcome and it will add much to the interest of the meetings.

There seems to be no question as to the necessity of an all time Secretary with an assistant and suitable quarters for the work. Those who have experience in the affairs of the Association can not understand how the Secretary has done the work for so many years, nor will the members ever realize the personal sacrifice made by Mr. Diven.

At the beginning of this administration it seemed certain that a deficit would be incurred owing to the increased expenses of the Secretary's office and the expense in printing the JOURNAL, due to the work of the Standardization Council. So much of the work of preparation, however, has been done by the members of the Council without expense to the Association that the Council has used only half of the budget allowance and the year's work shows a surplus. The work of the Council is now at full speed and the completion of their work will most certainly incur heavier expense for the ensuing year.

In the opinion of some of the members of the Executive Committee the Association should live entirely within its income. This may be impossible if we are to complete the work which the Standardization Council has planned. As this is the big effort of the Association it must be put over promptly to be of credit to this body.

The May issue of the JOURNAL is a full and ample answer as to merit of the work done by the Council.

In every day affairs there are few of us who would hesitate at taking slightly from a healthy surplus to complete one of the most important projects we had ever undertaken. Nothing should be done in any way to lessen the enthusiasm of the members of the Council in their work.

To one who has been in touch with the work of the Council it is surprising to see the amount of time and effort that has been given by the members of the several sections of the Council. I wish to give my humble praise to their splendid leader and to his able assistants in the work of the Standardization Council.

I wish to thank the Editor and the members of the Publication Committee for their splendid work, evidenced by the excellent program before you. Few members realize the immense amount of work done by this committee and we are fortunate indeed to have such an efficient corps of workers.

The individual effort of the Secretary in increasing the membership will meet the approval of all but the Secretary himself. While the work is not up to the mark aimed at, it will compare favorably with that of former years.

I wish to thank you all for the kindly manner in which I have been received. If I have been instrumental in restoring some of the good will and harmony to the Association, I have not labored in vain. While this meeting promises to be the largest in the history of the Association, let us all work for a better meeting next year and each succeeding year in order to keep the Association in the front rank of development and progress.

PROPER EQUIPMENT FOR PUMPING STATIONS[1]

By Arthur L. Mullergren[2]

The objective in the design of a pumping plant is the selection and installation of such equipment as will give the most reliable and adequate service at the lowest possible cost, taking into consideration all fixed charges and operating costs. The modern pumping station is similar to the electric power station in that both are called upon to deliver essential commodities continuously and adequately at a minimum of expense. The pumping station is somewhat different, in that reliability of service is the prime requisite, as continuous service must be given at all times even at a sacrifice of economy. However, economy never has to be greatly sacrificed in a well designed station. The three principal factors to be considered in the design of a pumping station are in the following sequence: first, reliability; second, adequacy; third, economy.

Reliability may always be obtained by the selection of the best types of equipment known and by duplication of all parts throughout the installation.

Adequacy may always be obtained by using liberal sizes of equipment and appurtenances.

The economy, however, is affected by the first two factors, in that unnecessarily expensive equipment might be selected for the particular installation and avoidable duplication made, as well as by installing equipment too large for the particular requirements.

There is a happy medium to be reached by properly proportioning and selecting the various equipment for each particular installation that will give adequate and reliable service at an economically satisfactory annual overall cost. Therefore, in designing a pumping station, the three factors mentioned above should be carefully weighed in the determination of each piece of equipment that goes into the station.

[1] Presented before the Detroit Convention, May 22, 1923.

[2] Consulting Engineer, Kansas City, Missouri.

Inasmuch as the overall economy of a station depends upon delivering the required quantity of water at the required pressure with the least possible fuel and labor charges, in addition to the fixed charges, it is important that careful consideration be given to the various component parts of the station equipment so that the completed station will give the results desired. In some instances it is impossible to secure a highly economical installation, due to location of plant and space requirements. A water pumping plant must always be located with regard to available supply, regardless of the desirability of the location from an operating standpoint. The location of a plant generally has some effect upon the type of equipment selected and consequently each particular location requires careful consideration. When considering the reconstruction or rehabilitation of an existing plant, a greater overall plant and system economy may be secured by selecting a different site. In some cases it is possible to have a choice of a half a dozen different locations, from a water supply standpoint, and, in such cases, the determination of the site may be made from a purely operating standpoint.

There has been marked improvement in the design of pumping machinery and power station equipment in the last few years. Until very recently, for very large pumping stations, the vertical triple expansion flywheel pumping engine has been pre-eminent from an economic and mechanical standpoint. This type of engine under favorable steam and water conditions has reached a duty exceeding 200 million foot pounds per thousand pounds of steam. These engines have been very reliable and their maintenance cost low. They require, however, expensive buildings and foundations and the investment is high. The installation of such engines is prohibitive in the smaller plants, owing to the high fixed charges. The annual fixed charges on this type of pumping engine will exceed $700 per million gallon daily capacity. With the marked development in steam turbines in the last few years and the improvements in the design of centrifugal pumps, the steam turbine driven centrifugal pump has reached an overall economy that will exceed the vertical triple expansion flywheel pumping engine, where favorable steam conditions are obtainable. There is no question now as to the reliability of the steam turbine, as the general electric power stations use this type of prime mover exclusively and have used them for a sufficient time to demonstrate thoroughly their usefulness as a reliable

and economical source of power. There is no question as to the reliability of the centrifugal pump and the designer. of these pumps have now increased their efficiency to a high state—reaching as high as 86 per cent. One of the difficulties formerly encountered in the turbine driven centrifugal pumping unit was the gearing used to reduce the pump speed to a satisfactory point. The double helical reduction gear now employed for this purpose has overcome this difficulty, as such gears have an efficiency of 98½ per cent and operate with little noise and maintenance and apparently have a life equal to the unit. The steam turbine is admirably adapted to high steam pressures and high superheat, as well as a high vacuum. With the increasing tendency towards higher steam pressure and higher superheat, the turbine pumping unit will naturally benefit in economy to a greater extent than the reciprocating type of pumping engine; consequently, there will be an improvement in the duty of the turbine pumping unit as improvements in the boiler plants are made. Materials capable of withstanding a total steam temperature of 750°F. are commercially used in turbines, boilers and piping, and this temperature seems to be about the commercially practicable limit at present, although there is considerable research work being undertaken to develop materials capable of withstanding much higher temperatures. The highest duty probably reached so far under an actual operating test by a turbine centrifugal pump was that of a 30 million gallon centrifugal pumping engine at the Mount Royal Pumping Station, Baltimore, Maryland. The duty reached by this engine on test was 170 million foot pounds per thousand pounds of steam, when delivering water at the rate of 45 million gallons per day at a pressure of 180 feet with a steam pressure of 172 pounds superheated 53 degrees Fahrenheit and a 28.9 inch vacuum. The City of Omaha, Nebraska, has recently contracted for the installation of a fifty million gallon per day, 280 foot head, steam turbine centrifugal pump and the manufacturers have guaranteed a duty of 189 million foot pounds per thousand pounds of steam, based on 250 pounds steam pressure at 150°F. superheat and 70 degree cooling water. This duty is exclusive of the condensate pump and the hurling water pump for the hydraulic air ejector, which two pumps are direct connected on one shaft to a 24 brake horse power steam turbine operating non-condensing. The duty included, however, all other auxiliary equipment used by the pump, condenser and turbine. The non-condensing steam turbine for driving the aux-

iliaries mentioned is used to secure a proper heat balance in the station. Consequently, the total station duty will not be affected and may possibly be improved.

In most of the larger pumping stations built in the last year or so, the steam turbine driven centrifugal pump has been installed. The tendency is decidedly towards the use of this type of equipment, and, in view of the very recent marked improvements in economy and design, together with the improvement in economy by the use of higher steam temperatures, I predict that, in less than ten years, the reciprocating type of pump will have a limited field and the number used will be negligible. Centrifugal boiler feed pumps, both steam turbine and electric motor driven are quite common now, and there has recently been developed a satisfactory small steam turbine for stoker drive.

The large central electric power stations have made great improvements in overall plant economy. This improved economy has been secured largely through improvements in the boiler plant equipment. An overall plant thermal efficiency of 20 per cent has been reached, and it is expected that 25 per cent will be reached shortly. The boiler plant has always been and is yet the least efficient part of the pumping or central power station, and power plant engineers are making a great effort to improve the efficiency of this part of the plant. Larger boiler units are being installed with higher steam pressures and higher superheat. Furthermore, the tendency is to operate the boilers at much higher ratings, which keeps down the investment and fixed charges and the thermal efficiency of the boiler is not seriously affected. The central station engineers have been endeavoring to secure as near as practicable a perfect heat balance in the station, which, of course, increases the overall plant economy. This is attained by utilizing the greatest possible number of heat units of the fuel and returning the condensate to the boiler at the highest possible temperature. In a recent boiler installation made in a central station, the furnace walls were lined with cast iron blocks surrounding steam tubes through which the boiler water circulated. It is expected that the additional heating surface furnished in this manner will give a much higher overall boiler efficiency, due to the fact that more of the heat units of the fuel will be utilized. It is furthermore expected that the furnace maintenance expense will be reduced over the regular fire brick lining which is always a sourc of expense. The judicious use of economizers has

also considerably increased the boiler plant efficiency. Recent tests indicate that greater plant economy may be secured by bleeding the main turbine units at the lower stages for feed water heating than by using small steam non-condensing auxiliaries for this purpose. In fact, better overall results were obtained by bleeding a sufficient amount to secure the required feed water temperature than by using economizers and steam driven auxiliaries or house turbines. This bleeding also relieves the lower stages of congestion. Either electric driven or waterwheel driven auxiliaries may often be used to better advantage, from an installation as well as an economic standpoint. In water works stations, the waterwheel driven auxiliaries with hydraulic air ejectors, returning the cooling water to the suction of the main pumps, offer simplicity and economy. Only the largest pumping stations, however, would be warranted in boiler plant installations similar to that used in the best type of central stations, but in many cases it would be possible to secure a greater overall station economy by the use of central station methods and equipment adapted to the particular condition.

There are now on the market meters for the boiler room that will record fairly accurately the various operating conditions of the boiler plant, making it possible to check up any unusual loss occurring therein. A modern boiler room should contain all such meters as will enable the operating engineer to tell the condition of his combustion, water temperatures, output and any defects in his equipment. While we are at present getting good thermal efficiencies out of our individual boiler plant equipment and the prime movers, there is room for considerable improvement in the overall plant economy. A gain of a few per cent in efficiency in each part of the plant may mean a considerable reduction in the total annual expense. Consequently, when it is possible to make a small gain by improvement to any part of the plant equipment, it is advisable to do so, as the various improvements made regularly will ultimately make an excellent showing in the plant operation.

In the determination of the equipment for a pumping station, there has been a tendency to select a highly efficient pumping unit sometimes without regard to the adaptability of the unit to the conditions under which it will operate and particularly without regard to economic considerations. At the same time the boiler plant equipment and auxiliaries are selected with little thought. The pumping station should be considered as a unit and all equipment entering

into its construction should be carefully selected with regard to adaptability and economy of the various parts with respect to each other and to the whole. Much publicity has been given at times to the high thermal efficiency reached by some pumping units, and, in some cases, the overall thermal efficiency of the plant has been commented upon. Our goal has apparently been to secure a high duty per B.T.U. If the efficiencies of some of these plants had been measured in duty per dollar of annual charges, they probably would not have made such a satisfactory showing. After all, the duty per dollar of annual charges is the true measure of efficiency of the pumping station, and in the selection of the equipment for a station, this should be the basis of calculation.

Since the development of the central station to its high degree of efficiency and of the extensive transmission systems emanating from such stations, there are conditions where electric motor driven pumping plants would show a considerably higher duty per dollar of annual charges than a highly efficient steam plant. This is particularly true in the smaller installations and where electric power is available at reasonable rates. Where synchronous motors may be used, central stations are offering attractive rates to the water pumping plants, as this type of motor assists in correcting the power factor of the transmission system, and the hours for pumping can be, in a great many cases, arranged to suit the central station. Motor driven centrifugal pumping units have been installed that have shown efficiency of 82 per cent, which is a good showing when we consider that the mechanical efficiency of a vertical triple expansion flywheel pumping engine is about 93 per cent. Reliability of service is one of the principal reasons that electric drive has not been more generally adopted. With the duplicate or loop transmission lines and interconnected central stations, however, practically as great a reliability as in the self contained plant will be secured. Furthermore, emergency equipment operated independently by an inexpensive steam or oil engine installation may be provided, thus insuring absolutely continuous service. By carrying the fixed charges on this emergency equipment together with the small amount of operating expense that may be incurred in its operation, plus the regular operating expenses and fixed charges of the electric driven plant, the annual charge of the entire installation may be considerably under the annual charge of a highly efficient steam plant. Some of the larger central stations have their plants installed at the coal mines and own these mines,

consequently their fuel costs are not subject to the wide fluctuations of the average water pumping plant. As a result, by considering the annual operating and fixed costs over a period of years, the purchase of electric power will be in a great many instances considerably under that of producing the power. Superpower plants and systems are being built and the greater the system, the greater the advantages of purchasing power over producing same with isolated plants. The pumping stations located in these superpower zones may well look to electric driven equipment, or a composite electric and steam driven plant so arranged and operated as to take advantage of the low power costs, low fixed charges, flexibility and simplicity of operation.

The Diesel type oil engine has been developed to a high state of efficiency and reliability and, in certin localities, this type of pumping plant would probably make an unexpected showing, insofar as the annual costs are concerned. The investment in this type of equipment is high, but the fuel economy is high, such engines reaching a thermal efficiency of 35 per cent, and, in localities where coal is expensive and electric power is not available at satisfactory rates, it would pay to investitate the feasibility of such an installation before definitely determining upon any type of plant.

In stations having a daily capacity of ten million gallons and above and with coal costs around $6.00 per ton, the high pressure steam driven centrifugal pump will ordinarily show the best duty per dollar of annual charges, over any other isolated type of plant. In plants below this capacity, each particular installation would require thorough investigation and careful balancing of all costs, before a definite type of plant could be decided upon. It is generally recognized that, in plants of three to five million gallon daily capacity, the cross compound flywheel pumping engine will make the most favorable showing. In regard to thermal efficiency, this may be true, but it would not hold in every case if the duty per dollar of annual charges were considered.

In conclusion, I might say that definite annual cost data on each type of plant for different conditions would be of considerable value in supporting the above, but there are so many different conditions and so many different types of plants to be considered for each particular condition, that it would require considerable space to present.

The point that I wish to emphasize in this paper is that, in the selection of the various equipment entering into a pumping plant, instead of endeavoring to select the individual plant units having the

highest thermal or mechanical efficiencies, or even securing the highest total plant duty on a heat unit basis, the completed plant should give the highest duty per dollar of annual charges, in which would be included all operating expenses, maintenance, interest, depreciation, insurance and any other fixed costs, taking into consideration at the same time the reliability, adequacy and future growth of the plant.

THE PREVENTION OF CORROSION IN HOT WATER SUPPLY SYSTEMS AND BOILER ECONOMIZER TUBES[1]

By C. R. Texter[2]

INTRODUCTION

In the present era, which has been referred to as the "age of iron," one of the most important industries is the production of iron and steel. Indeed the use of ferrous metals is so universal that it would be extremely difficult to imagine how we could possibly do without them. Realizing, therefore, the importance of iron and steel and the vast tonnage produced annually, it seems unfortunate that they are so unstable when exposed to the ravages of nature and that so many iron and steel commodities have to be replaced every few years due to corrosion, or rusting, as it is commonly called. But that this is a fact is shown strikingly by the following estimates of two authorities on this subject.

F. N. Speller[3] has made some careful investigations in the United States and has found that from one to two million tons of steel are totally lost annually in this country due to corrosion, while Sir Robert Hadfield[4] gives the astounding figures of twenty-nine million tons as the annual loss of steel over the entire world. Furthermore the cost of the metal actually lost, represents only about one tenth of the total expense involved, when replacements are necessary.

These figures are indeed staggering and almost unbelievable, but even though such estimates can be only approximate, yet they are near enough to the truth to cause us to give the subject some serious attention.

The most logical thought arising in the minds of practically all of us will be a consideration of the steps which might be taken to

[1] Presented before the Chemical and Bacteriological Section, Detroit Convention, May 24, 1923.

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[3] Speller, F. N., Metallurgical Engineer, National Tube Company, Pittsburgh, Pa.

[4] Hadfield, Sir Robert, London, England.

mitigate the evils of corrosion and of how it may be entirely prevented. This is a subject which is so extensive and which leads us into such diversified uses of iron and steel that it would be impossible to discuss it in all its aspects. Therefore, this paper will be confined entirely to the prevention of corrosion in steel or iron pipes carrying hot water, and more particularly in hot water supply systems.

In considering any phase of the subject of corrosion, it seems of primary importance, and at least of academic interest, to make some mention of the theory of this phenomenon. Although this paper does not have for its purpose a lengthy discourse upon the theoretical side of the subject, there is no doubt that it will be helpful to discuss briefly the fundamental reactions underlying the deterioration of iron and steel in water.

Various investigators have propounded different explanations as to the causes of corrosion; but, regardless of the theory to which we pin our faith, there is good evidence for the assumption that the first reaction taking place, when iron is placed in pure water, is a slight dissolving of iron in the water. This passing into solution of iron is accompanied by the transfer of a positive electrical charge to the iron (Fe) from the hydrgen (H) which is formed during the dissociation of water into H^+ and OH^- ions. This reaction may be simply represented by the following equation:

$$Fe + 2\,H^+ = Fe^{++} + 2\,H.$$

The hydrogen covers the surface of the iron with a polarizing film, which protects the metal from further solution or corrosion unless removed by some external force. In a natural water, i.e., a water which is not acid, the removal of this hydrogen film requires the presence of dissolved oxygen in the water, the oxygen uniting with the hydrogen and thus exposing the bare metal to further solution by the water.

FACTORS INFLUENCING CORROSION

Without delving more deeply into the intricacies of theoretical chemistry, therefore, we are led to the conclusion that the corrosion of iron and steel in ordinary natural waters depends upon the presence of oxygen (air) in solution, and that this fact must be recognized as of primary importance in attempting practicable means for the prevention of corrosion in hot water supply systems or in steam power plants. In other words, water and oxygen are essential factors in the rusting

of iron, and it has been shown by Walker and his co-workers[5] that the rate of corrosion of steel or iron immersed in pure water is directly proportional to the concentration of the dissolved oxygen.

Of course, when speaking of the presence of water and oxygen as necessary for the continuation of corrosion, we must not lose sight of the fact that the water carrying the oxygen must be in intimate contact with the metal and not separated by a protecting layer of scale.

This scale or film may be of considerable thickness, or it may be only microscopic, but in any case its presence or absence is a vital factor in determining the relative corrosiveness of different waters. For instance, in New York City, where the water is very soft, steel and iron pipes in hot water supply systems last only a few years, while in the cities using water from the Great Lakes, the same pipe may be used under the same conditions from three to five times as long. The explanation of this is that the Great Lakes water is high in calcium bicarbonate, which is thrown out in the hot water supply lines as a hard scale of calcium carbonate; while the New York water contains little or no scale forming constituents. The practical application of an artificial scale-forming substance to hot water tanks as a protection against corrosion, is being perfected at the Mellon Institute of Industrial Research of the University of Pittsburgh and will be discussed later in this paper.

Still another important determining factor in the rate of corrosion is the temperature of the water. Speller and Kendall[6] have shown that, with pure water, the rate of corrosion in closed water systems under pressure increases directly with the temperature.

PREVENTION OF CORROSION

After becoming familiar with some of the more important factors influencing corrosion, the question of prevention may be approached more logically. There seem to be but two primary avenues of attack. The water itself may be rendered less corrosive, or the pipe may be made more resistant to corrosion by changing its composition, or by the application of some protective coating.

[5] Walker, Cederholm, and Bent, J. Am. Chem. Soc., **29**, (1907), 1259.

[6] Speller, F. N., and Kendall, V. V., A New Method of Measuring Corrosion in Water, Ind. Eng. Chem., **15**, (1923), 134–39.

Taking these up in order and referring back to the reactions mentioned in the first part of this paper, it is found that the presence of dissolved oxygen in the water, provided the water is not acid, is absolutely necessary for the continuation of corrosion, at least in iron and steel pipe, and probably in the case of the non-ferrous metals also. Recognizing, therefore, the important bearing upon corrosion of the presence of dissolved oxygen in natural waters, the question resolves itself primarily into one of oxygen removal or de-aeration.

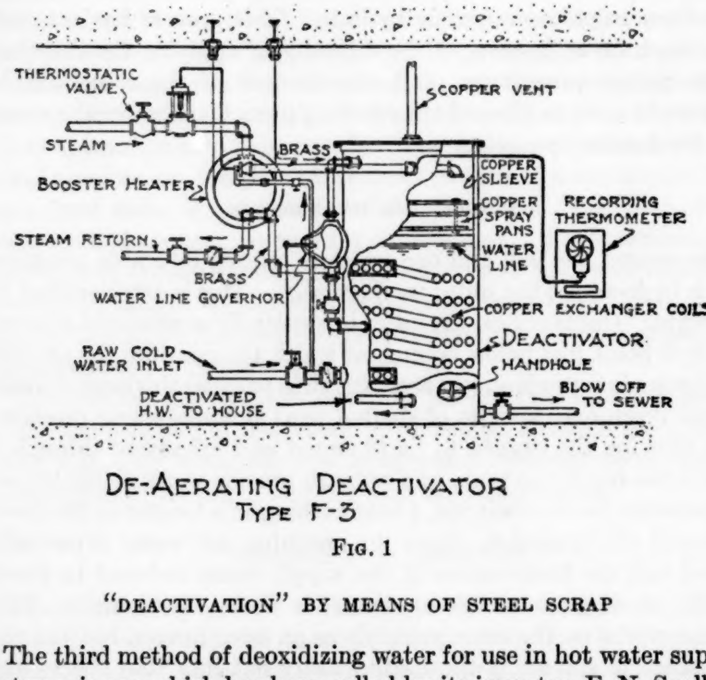
Generally speaking, there are three methods used to accomplish this end. One procedure is to remove the oxygen chemically, by adding to the water some compound which is readily oxidized, such as sodium sulphite or ferrous hydrate. This process has not met with much favor, because of the difficulty of applying the chemical in the proper proportions, and also because of the objectionable feature of having to filter off the resulting precipitate before the water is fit for domestic purposes.

MECHANICAL DEAERATION

The second method, and one which is coming into wide practical use, is to de-aerate the water mechanically. This is accomplished in two ways. One is to heat the water in a specially constructed apparatus, to a point just below boiling, at which temperature the solubility of gases in water is almost zero, and then to cause this heated water to spill down over a series of shallow pans at atmospheric pressure, thus allowing the oxygen to be liberated and exhausted through a vent in the top of the tank. In order to provide water at the proper temperature for domestic use, a heat exchanger is located in the lower section of the apparatus, where the incoming cold water is partially heated and the temperature of the supply water reduced to about 150°F. A diagram of the apparatus is shown in figure 1. This process works on the same principle as an open heater, but has the advantage of spreading the heated water out into thin sheets and giving the gases every opportunity of escaping.

The other way of mechanically de-aerating water is somewhat the same as that just described, with the exception that the water is not heated to such a high temperature and a vacuum is employed. Substantially, the process is to heat the water to a predetermined temperature below its boiling point and then suddenly admit it into an evacuated chamber, the degree of vacuum being predetermined in

consideration of the water being admitted. The water entering this evacuated chamber, being super-heated, immediately flashes into vapor, thus liberating the oxygen as well as all other gases. The water vapor and gases then pass into the condenser, where the vapor is condensed by cold water going to the heater and the non-condensable gases are drawn off by means of a pump. This type of apparatus as shown in figure 2, is capable of reducing the oxygen to 0.2 cc. per liter or less. Water carrying such a low oxygen concentration is very desirable for use in boilers equipped with steel economizer tubes.



DE-AERATING DEACTIVATOR
TYPE F-3

FIG. 1

"DEACTIVATION" BY MEANS OF STEEL SCRAP

The third method of deoxidizing water for use in hot water supply systems, is one which has been called by its inventor, F. N. Speller,[3] "deactivation." In brief, the method consists of fixing the oxygen by means of a storage tank filled with an easily corrodible scrap iron or steel in suitable form, such as steel lathing. The water is heated in an ordinary hot water heater to about 160°F., and then allowed to circulate through the tank containing scrap iron, to which the water gives up its oxygen, thereby expending its corrosive energy. In other words, the water does all its rusting in one place and comes out

of the "deactivator" incapable of causing further corrosion in the pipe lines. The water, before being used in the system, sometimes, and especially when it is destined for domestic use, must be filtered in order to remove suspended or colloidal iron. One type of deactivator is shown in figure 3.

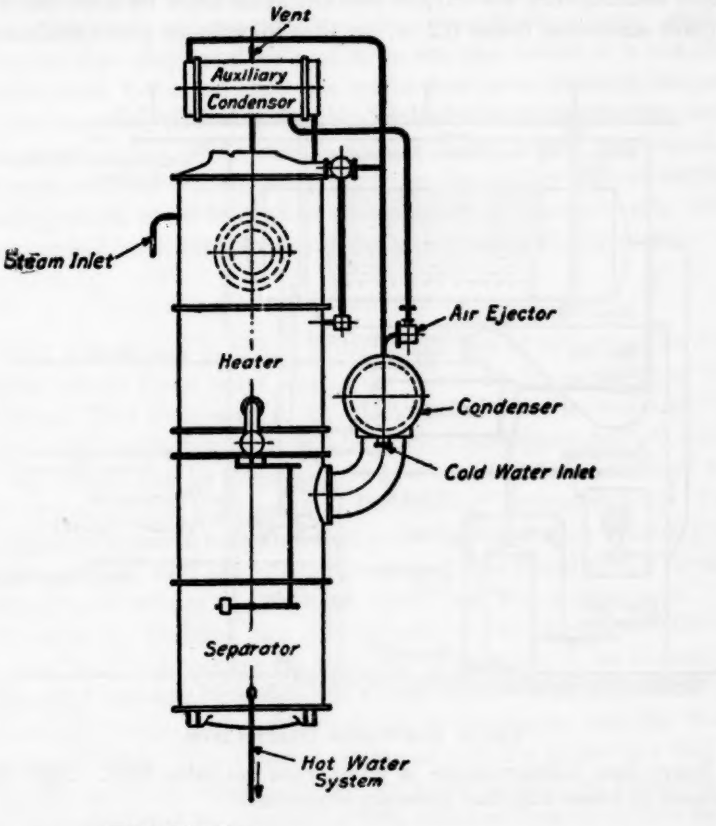


FIG. 2. DEAERATOR OPERATING AT REDUCED PRESSURE

The size of the deactivating tank depends upon the temperature of the water, but for the average system (about 160°F.), it may be stated roughly that the tank must be large enough to provide storage capacity for one hour's supply of water. By this process it has been found that the oxygen content of the water is reduced from an average

of 7 cc. per liter to less than 0.5 cc. per liter. Long period tests have shown that if the oxygen concentration in a hot water supply system is kept below this point, the life of steel or iron pipe will be increased about ten times over that of pipe carrying water saturated with oxygen. For excessive temperatures, as found in steam boilers and boiler economizers, the oxygen concentration must be kept down to a point somewhat below 0.2 cc. per liter in order to give satisfactory

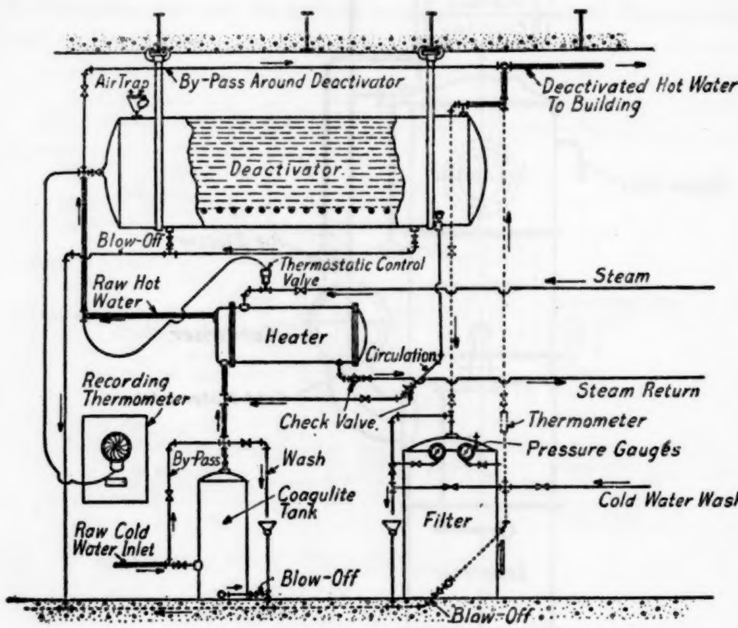


FIG. 3. HOT WATER DEACTIVATOR

Heavy lines indicate course of water when not using filter. Light lines indicate by-passes and other necessary connections.

protection to the tubes. The best practice is to use water carrying absolutely no dissolved gases as delivered by the vacuum-type deaerator briefly described above.

PROTECTIVE COATINGS

The other method of preventing corrosion upon the internal surface of steel pipes carrying hot water, namely, by the application of

protective coatings, may be considered as including metallic and non-metallic coatings.

Among the metallic coatings applied to water pipe are zinc and aluminum. The chief non-metallic coatings are cements and a variety of asphalt and coal tar preparations. These all have their special adaptations and uses and much could be written about each one of them, but space will not permit of their consideration here. Suffice it to say that they must be applied to the pipe before it is put into service, and, therefore, once the water has eaten through the protective material, there is no chance for its renewal and the bare steel is exposed to the destructive action of water. This short-coming of most artificial coatings suggested the desirability of a protective coating which could be applied continuously or intermittently after the pipe had been put into service in the hot water supply system.

"SELF HEALING" PROTECTIVE COATING

With this object in mind, a particular line of investigation was started about three years ago in the Research Department of the National Tube Company, in an effort to find some material which, when added to the heater, would be carried throughout the hot water supply system and be precipitated out upon the internal walls of the iron or steel pipe in the form of a "self-healing" protective film. The preliminary research indicated that soluble silicates were well adapted to this purpose, and after numerous tests it was found that a certain form of fused silicate of soda most nearly met the requirements.

In order to facilitate the development of this so-called "silicate process" and to determine the best way of applying it, an Industrial Fellowship was established about a year ago at Mellon Institute of Industrial Research of the University of Pittsburgh and the work continued there. The value of silicate of soda lies in the fact that it is readily carried in solution by the hot water throughout the system, and is precipitated by combining with colloidal iron or soluble salts in the water, in the form of an impervious film which prevents the corrosive water from coming into actual contact with the metal. One very important advantage of this process is that the treatment may be made continuous or intermittent as it is found necessary, the color of the water being a very good indication as to just how to control the operation.

The question might be raised as to the particular advantage silicate of soda has over any other alkali, such as lime or caustic soda,

in preventing corrosion. The reason for using the silicate is that, whereas any alkali has a tendency to build up a protective coating in pipes carrying hot water, yet it has been found that the film formed by silicate of soda is more adherent and less pervious than any other quickly deposited scale. It is also very permanent. This last statement has been well substantiated in the practical application of the treatment in the Mellon Institute hot water lines. At this place the silicate has been entirely cut off for periods of two or three consecutive weeks, during which time the water continued to run bright and clear at all times.

The "silicate process" has been in practical use for over two years in Pittsburgh and for somewhat over a year in New York and Boston and it has been demonstrated that the color of the water at the spigots has been changed from a yellowish red or even dark brown at times to absolute clearness in about a week's time. Furthermore, weighed test pieces show that actual corrosion is cut to one half or less. The treatment is applicable to old rusty hot-water heaters and almost worn out pipe lines, as well as to new installations, and is therefore found to be very advantageous for small apartments or dwellings where the "red water plague" is almost a nightmare to the inhabitants and for laundries where considerable losses are experienced on account of rust staining the clothes.

It must be borne in mind, however, that the "silicate process" is only applicable to small buildings where the length of piping in the hot-water supply system is relatively short and not to large buildings. Where the lines are of considerable length, it has been found that the protective constituent spends itself and is deposited in the part of the system nearer the heater and, in consequence, corrosion proceeds apace in remote lines due to the maintenance of a high oxygen content. Therefore, in large buildings, it is recommended that one of the systems of deoxidation be installed because, as has been said before, no protective coating method is as efficient as deoxidizing the water and thereby removing the real cause of corrosion in ordinary waters. The cost of deoxidation, however, makes the use of this method prohibitive in small systems. Accordingly it is the purpose of the silicate treatment to give a simple and effective means of retarding corrosion and providing clear water to laundries, small apartment houses and private dwellings.

THE PHARMACOLOGY OF WATER[1]

By H. C. Hamilton[2]

By using this expression, meaning the action of water on the animal or human organism, one admits water to the list of medicinal agents. Such inclusion does not necessarily refer only to water containing dissolved gases or salts, for water in itself has many properties and functions which should endear it to everyone. Its importance is indicated by the fact that the human body contains nearly eighty per cent of its weight of water in one form of combination or another and that this water content is almost invariable. Most of the food we eat such as meat, milk or vegetables is equally high in water content.

Without water in considerable quantity the digestive juices are not secreted in sufficient quantity for either absorption or elimination to proceed as they should.

In all this, water is just water whether distilled, hard, softened or mineral. No material difference results unless the water is distasteful. The presence or absence of salts or gases seems unimportant.

Chemically pure water is not of natural occurrence. Only distilled water meets this specification and this is so unattractive for drinking purposes that it may be dismissed from consideration. It is flat and tasteless, because it contains no salts or gases and, while as good as any other, it is of importance only in chemistry.

Water is so remarkable a solvent that gases, odorous substances and salts become dissolved in it, so that a palatable drinking water invariably contains some foreign substances. People from one locality rarely like the water in another. While the salts occurring in ordinary well or spring water are almost infinitesimal in amount they are capable even in these high dilutions of imparting a distinguishable taste to the water to which we become accustomed.

[1]Presented before the Chemical and Bacteriological Section meeting, Detroit Convention, May 24, 1923.

[2]Chief Pharmacologist, Parke-Davis Company, Detroit, Mich.

Water is highly essential to health. It aids digestion, elimination and the automatic regulation of body temperature. In the latter case it is remarkable how quickly a drink of cold, or even more rapidly, warm water reaches the skin and by evaporation cools the body; by dilution of the blood it aids circulation; by dilution of the food it aids digestion; by dilution of waste products it aids elimination.

The dilution of the food does not, as formerly supposed, dilute the acid and pepsin in the stomach. It increases their secretion and thus doubly aids digestion.

Water is scarcely at all absorbed by the skin although substances dissolved in it will often irritate the skin causing it to glow and thus draw away the blood from congested regions and aid elimination.

It is only slightly absorbed from the mucous membrane or the broken skin. In fact, distilled water or water free from salts will absorb salts from the mucous membrane and be decidedly irritating.

It is scarcely absorbed from the stomach, but is rapidly passed through to the intestines where it acts to dilute the food and promote absorption, to dilute the waste products and to prevent putrefaction by hastening their elimination.

From the intestines it is absorbed with remarkable rapidity and excreted by the kidneys. When taken warm and in large quantities it may be excreted by the intestines, thus acting as a quick and harmless purge. But the value of water in excretion is largely its diuretic effect. Even as high as 10 litres of water may be excreted by the kidneys daily without harmful effects. The beneficial effects are in diluting the urine to prevent irritation when the passages are inflamed and to prevent precipitation and formation of calculi.

The excretion by the skin, either as sensible or unnoticed perspiration, varies inversely with that by the kidneys and depends largely on exercise and temperature.

Excretion by the lungs varies little as the expired air carries a fairly uniform amount of moisture.

Large quantities of water may be taken with meals with no harmful effects. The benefits of water drinking with meals are increasing the flow of digestive fluids, especially pepsin and acid in the stomach, hastening, and increasing absorption of food leaving less in the intestines for bacterial decomposition. Drinking water also allays the pain of hunger contractions. In all cases food may better be withheld than water. When water is withheld, aside from the discomfort or thirst and the effects the opposite of those described above, there is an increased destruction of the products of metabolism.

The underlying reason for some of the deleterious results of withholding water is obscure.

Thirst (for water) is a response to the concentration of salts in the tissues, a lessened flow of saliva and the drying of the mucous membrane. The body is about 70 to 80 per cent water and the ratio suffers very little change without discomfort. It follows, therefore, that the elimination by kidneys and skin must be promptly restored.

Here we may note again the solvent action of water and the prompt passage through the membranes by osmosis of the solution of salts of high to those of low concentration by which the salt content of the tissues is reduced.

Not less important in connection with metabolism is the fact that it is only in solution that the digestive enzymes act; it is only the dissolved or suspended material that is absorbed; it is only the moist air that is passed through lung tissue.

Hydrolysis and the reverse is almost a constant process in metabolism. This is the means by which the complex molecules of protein are reduced to the simple amino-acids capable of assimilation. Even as simple a substance as sugar requires the addition of a molecule of water to transform the disaccharide molecule to two monosaccharide molecules which are absorbed and utilized by the body; but not until this simple combination replaces the more complex one does any absorption take place. Practically every change in composition in the processes of metabolism involves the release of molecules of water or else hydrolysis.

While water no longer occupies a high place as one of the four elements of the ancients, what it has lost in reverence it has gained in recognition of its utility. Few chemical or biological reactions occur without water. Even the action of insecticides and germicides is largely dependent on the presence of moisture. Absolutely dry formaldehyde gas or sulphur dioxide have no effect on dry bacteria; absolute alcohol is equally ineffective, but with moisture each of them assumes the rôle of an active germicide.

Whenever permeability of tissues is involved, moist tissues and solutions in water are essential, for otherwise the tissues may be attacked or the salts may irritate or at the very least no response may follow the introduction of dry substances to the stomach, intestines or tissues.

Water containing gases, as carbon dioxide or hydrogen sulphide, are often used for their medicinal effects.

Carbonated water, either natural or artificial, stimulates the stomach to increased activity by a mild irritation, increasing absorption and necessarily elimination. It aids in expelling gas from the stomach and intestines. It is more palatable than ordinary water and often is used in fever or where extra elimination is demanded. Carbonic acid gas has no physiologic effect, as it is exhaled so rapidly.

Carbonated bath water slightly irritates the skin, but has no other observed effects.

Sulphur springs contain a small proportion of hydrogen sulphide and alkaline sulphides and are highly recommended for respiratory and skin diseases, syphilis, gout, rheumatism and metallic poisoning. It is more than probable that all the benefits derived from such waters are due to the heat of the water and the prolonged and frequent baths rather than any specific effects of the sulphur. It should not, however, be condemned on that account but rather recommended for any virtue that will increase the use of the water. The gaseous content is indirectly a benefit and may aid the mind to respond to the action of the water.

When one considers the minute amount of the substances contained in water and attempts to estimate the effect on the system of their ingestion, only a vivid imagination or supreme faith in the principles of Homeopathy, as exemplified by the subdivided dosage, will recognize any value in them. This takes no account, of course, of bacterial content, which is another matter. For bacteria ingested under conditions ideal for themselves may be very serious for the unwitting host.

Water containing a single salt in solution is more or less toxic to animal life. The mineral constituents of cells are, therefore, indispensable to life. Animals require sodium, chlorine, carbon dioxide, calcium, magnesium, iodine, iron, phosphoric acid and sulphuric acid. A diet free from inorganic salts causes a continuous decrease in weight. The substances noted above are not equally necessary, for calcium and phosphorous may partially replace all the others without any disturbance in metabolism, but may not themselves be replaced. These salts may or may not be abstracted from water containing them, but it is more probable that they are not.

The most important feature in connection with mineral waters is that for one reason or another larger quantities are imbibed than of ordinary water. This is partly due to the pleasant or characteristic taste, partly to the routine prescribed by the physician and partly

to giving oneself up to the course of treatment and making the most of it.

Probably all the good of mineral waters would result equally from the similar use of any water, but this should not detract from the use and exploitation of mineral water for those who can afford it. The psychology of the treatment really requires a mineral water.

The ascribing of mysterious virtues to mineral water is without basis. The use of it at the springs instead of at home is not essential for developing its medicinal value. But scarcely indeed will the use be continued under the best conditions unless under the direct control of the attendants. Often, too, climatic and hygienic conditions are more nearly ideal and of no less importance than the water itself.

The reputed existence of a goiter region, in which the water is said to be deficient in iodine, seems to disprove the uselessness of a mineral content. If this is actually proved, it will go far toward establishing the value of mineral waters. Data on this point have a tendency to be colored by prejudgment not amenable to reason.

Hard water containing sulphates and carbonates of lime and magnesium seems to have no deleterious effect on those using it almost exclusively. In excessive quantities, however, these salts may exert their typical effect on a person not accustomed to them.

To all intents and purposes, pure water for drinking requires only bacteriological purification, unless some absorbable poison is present, and most forms of purification are aimed at reduction of bacterial content. But hard water is so objectionable as a cleansing agent, because of its action on soap, that in some localities this is no less important than the bacterial content. The soap destroyed by hard water is nearly ten times the weight of the constituents responsible for the destruction.

We may conclude, therefore, that any adventitious circumstance under which water is used or any peculiar property, actual or imaginary, which will encourage a greater use of water, either internally or externally, is not to be underestimated in its bearing on health. Further, few substances occurring in a natural water render it unfit for drinking purposes, except the presence of pathogenic organisms responsible for intestinal disease.

METHODS OF OBTAINING RECORDS OF STREAM FLOW FOR MUNICIPAL AND INDUSTRIAL PURPOSES.[1]

By C. C. Covert[2]

It is not the purpose of this paper to discuss the technical side of stream gaging work, but to present the subject in a manner that will create greater activities among engineers, plant superintendents, and others who may have an opportunity to assist in the work of obtaining for the further benefit of the nation, data which will enable the engineer of tomorrow to solve in as efficient a manner as possible, the engineering problems which have to do with the use of water, and which will become more and more intricate as the years go by.

As a nation we have been traveling very much in the dark concerning the use of our water resources. Although the surface water supply and the underground water supply are without doubt the most valuable of our natural resources, we have been giving them very little attention.

We have been traveling along a road that has had many turns and some diverting paths. The signs have not been so placed as to guide us always in the right direction, yet, as long as the supply has been sufficient for the needs, we have been able to make some progress. However, if we take the time to go back over the trail, we shall find ruins along the way. Mistakes and failures relating to water supply projects, as well as to water power development, will be found far too frequent, I fear, to give us just the kind of picture we should wish to flash on the world's screen. Almost always these mistakes may be charged to a lack of stream flow records.

The World War, coupled with labor conditions, has indicated a new path which intersects the one we have been traveling in such a manner as to attract the attention of others than the engineer. But the question is, has our past experience been such as to enable us to

[1] Presented before the Detroit Convention, May 22, 1923.

[2] Hydraulic Engineer, W. & L. E. Gurley, Troy, N. Y.

see the light, take the more direct course to the ultimate goal, and so mark the trail that it will be continually growing better.

To do this, one basic principle must be firmly established in the minds of both engineer and layman. The basis for the solution of any stream flow problem is the reliable record of the annual discharge of the stream and its seasonal distribution. The longer the record, the surer will be the conclusions concerning any problem considered. Knowing this to be true, we still must face the fact that the United States has surprisingly little reliable information available for public use.

Until within the past decade little attention has been given to the work of obtaining records of stream flow by others than the engineers of the United States Geological Survey. Because of meager appropriations, the Survey work has been decidedly limited. In spite of the many handicaps under which these engineers have labored, however, we are indebted to them for practically all the reliable records now available, and for the methods used in obtaining those data.

The methods used by the engineers of the Water Resources Branch of the United States Geological Survey have been adopted by the leading Governments throughout the World. It is highly desirable that all similar data be collected as nearly as possible by the same methods and with the same degree of accuracy. This feature is an incentive for cooperation with the Survey engineers and has been one of the outstanding inducements for the extensive cooperation now enjoyed in those areas where the greatest degree of activity in the field of stream flow investigations is maintained.

From the standpoint of efficiency, it would be well for all public service corporations, municipalities and others interested in, or having to do with, any problems which involve the use of water, to seek cooperation with the engineers of the Survey, to the end that all such data may be collected in a manner which will permit of the records being published in the official reports or Water Supply Papers that are issued by the Federal Government. This cooperation cannot be urged too strongly, since it insures the services of an experienced engineer in locating the station and in designing and placing the equipment. This feature is essential to good records, for without proper location and proper field equipment at the station, complications are certain to arise which may discredit all, or at least a part, of the records obtained.

LOCATION OF GAGING STATION

A thorough reconnoissance is necessary in connection with the establishment of any gaging station. The engineer should be certain that he has selected the best site available. With modern equipment, one is no longer confined to the vicinity of some farm house or highway bridge. The recording gage and the cable way have practically eliminated these conditions as controlling features, and today we may select the location which will produce the best results. Of course, this may mean some additional expense at the start, but when we consider the value of the record and the fact that the station probably will be in operation over a period of years, the cost per year will not be a burden to any project.

The engineer who realizes the importance of a permanent control, well defined channel conditions, suitable place for metering and for the location of the gage, and gives all of these features mature consideration, will be able to reduce his operating costs and turn out final results—discharge in cubic feet per second—in a much more complete form.

The proper location of the gage with reference to the control is also of importance. Any interference here has much the same effect as shifting control.

The gage should not be placed so close to the confluence of a tributary stream that the readings will be affected by back water at certain stages, or on the up stream side of a bridge where log or ice jams may cause back water conditions.

TYPE OF GAGE

The type of gage is important. Some streams will be well taken care of with the ordinary staff or chain gage, while others will require recording gages. Often it is necessary to install a portable water stage register in order to determine this feature. When one has decided to use a water stage register, then to choose the proper type and to plan for its suitable housing is the next step of importance. Right here let me say that the shelter and the well should be more than toy structures. Many times I have seen an otherwise fine installation spoiled because of a small well or small shelter. There is no question as to the value of having a structure large enough to permit a man to enter, close the door, and work fully protected from the weather. Proper ventilation of both well and shelter is another

feature which should be given careful consideration. The well should be at least 3 feet or better, 4 feet square. In the northern countries it should be located well back in the bank where sufficient earth protection will assist in keeping ice from forming. If of timber, the structure should be of double plank separated by a layer of heavy tar paper. The shelter should be of the same dimensions, in cross-section, as the well. It should be built up of $\frac{7}{8}$ inch ship-lap covered with either tar paper or heavy building paper and then shingled. At least one window should be provided and this should be on a level with the gage. The window should be provided with a heavy board blind as a matter of protection. Stock doors may be used, but these should fit tightly and in the winter provision should be made to close this door so that the storms and winds cannot enter.

The intake pipe to the well is another important consideration. Four inch cast iron pipe or iron soil pipe is suitable for this use. The outer or river end should be anchored with a concrete pier. This end should also be covered with a screen to prevent as far as possible any foreign matter entering the pipe. After the trench for the intake pipe has been excavated, it is well to provide several wooden sills which may be placed crossways at the bottom of the trench, and underneath the pipe. Vertical supports fastened to these sills will form a support to the mud sill or bed board for the slope or outside gage. Each recording gaging station should be equipped with both an inside and outside gage, for the purpose of more economically and accurately checking the operation of the intake pipe. These gages should be referred by means of an engineer's level to some permanent bench mark. Recently I had the experience of checking up the gage height for a sender to a long distance water stage register. No outside or inside gage had been provided. This instrument had been operating with the water surface in the well nearly a foot higher than the water surface in the pond outside. This condition had not been noticed and, of course, no one had a complete history of when the change took place. Any records, therefore, which had been made by this instrument were questionable.

MAKING THE DISCHARGE MEASUREMENT

After the gage has been installed and is in operation, the next step of importance is the development of the rating curve. The Price Current Meter as manufactured today meets in a very satisfactory manner most of the problems connected with the regular stream

gaging work. When used under favorable conditions, and this the engineer must be on the watch for when choosing the site for the gage, there is no question but that the accuracy of the Price Meter is all that could be desired. Great care is exercised in its manufacture. All parts as now made are interchangeable and the pivot points on which the bucket wheel operates are subject to inspection under the projector, where the image of the point is thrown on a screen, the picture being magnified two hundred and fifty times, and the shadow must fit the prescribed form. This inspection insures as near a perfect pivot point as it is possible to obtain. Then with the Meter rated at the national Bureau of Standards, one has an instrument which is eminently qualified to meet the requirements of the engineer studying stream flow problems.

Frequently in the location of a gaging station, highway bridges or other structures suitable for use in making the discharge measurement will be found available. It often happens, however, that to secure the best location possible it is necessary to build some structure from which the measurements may be made. Standard equipment for this feature is a cable stretched across the river from which a car can be slung for the use of the engineer. Riding back and forth across the stream in this equipment, he is in a position to take observations of the velocity at any desired point. After each discharge measurement, the meter should be thoroughly cleaned and oiled.

For small streams and for low water conditions in the larger streams, it is often possible to make discharge measurements by wading. Measurements are made covering a range from low water to high water. The results of these measurements are then plotted on regular cross-section paper with the gage heights and discharge in cubic feet per second as coordinates, and through these points a smooth curve is plotted. From this curve one can compute the Discharge Rating Table, which when properly constructed, makes the problem of tabulating the daily discharge or, in some cases where the Water Stage Register is used, the hourly discharge, comparatively simple.

After the daily discharges have been taken out for the period of the record—usually these are worked up each year, at least—a tabulation is made which shows these results in monthly form, giving not only the daily discharge in cubic feet per second for each day, but the monthly mean in cubic feet per second, etc. When published in the Water Supply Papers of the United States Geological Survey, these data become available to engineers throughout the country.

MEASURING SMALL STREAMS

One of the important problems confronting the average superintendent, or engineer, of a water works plant, is obtaining accurate data on the run-off from small drainage areas. This problem is difficult to handle in those northern states where, during quite a portion of the year, the streams are more or less affected by ice. It has been my experience that the most satisfactory manner in which to handle this problem is to construct some kind of a weir and use this as a control, rating the weir in the same manner as you would rate a regular current meter station. The notch in the weir should be about large enough to carry the winter flow at a depth of 5 or 6 inches. The observer may easily keep the ice broken back for 6 or 8 feet from the weir and the records will be as accurate as in open water conditions. It will be found practically impossible to make discharge measurements with a current meter on small streams where they are covered with ice. Often the stream freezes to within a few inches of the stream bed and no opportunity is offered for using the current meter.

OBTAINING WINTER RECORDS

One of the features of importance in stream gaging work in the Northern States is obtaining winter records. At first it was not thought necessary to give much attention to the winter work, but as the engineer began to use actual records of discharge, rather than estimated records based upon rainfall and other climatic data, he also began to realize the importance of having a complete record throughout the year.

Mr. W. G. Hoyt, Hydraulic Engineer with the Water Resources Branch of the United States Geological Survey, developed a graphic method for this work which has been in use since 1913, and which when used by experienced men will give dependable results.

As soon as ice formation starts on the stream, it is necessary to begin to take discharge measurements to determine the back water effects, since any obstruction to the control is bound to cause back water at the gage. These winter discharge measurements should be made at regular intervals, the interval depending upon the character of the winter. In an area where there is considerable variation in temperature, more discharge measurements are required than in those areas where, after the winter starts, it is comparatively steady to the break-up period.

Special forms have been prepared by the Government for the winter work and on these forms one plots, first, the observed gage height; second, the mean daily temperatures; third, the daily precipitation (as reported from the nearest Weather Bureau Station to the gaging station); and fourth, on the curve of observed daily gage heights, the gage heights corresponding to the measured discharges as determined from the open-water rating table. The differences between these and the observed gage heights measure the backwater effects for the days in question. Fifth, the backwater effects, as determined under four, are plotted and through these plotted points construct a backwater curve, following the same general shape as the inverted temperature curve, taking into account the daily precipitation (if rain), ice jams, and other unusual conditions that may affect the records of stage. Sixth, from the backwater curve construct the curve of corrected gage heights, from which the true discharge may be obtained by applying the open-water rating table.

In conclusion, attention is called to the long distance water stage register. This instrument, while comparatively new, is of importance to all who may have reservoirs located at some distance, and who wish to have the record in the office or pumping house. This instrument is especially valuable in connection with a pumping station. The elevation of the water surface in the reservoir may be indicated in the pump house by the indicator, while the superintendent's office may have a continuous record of the changes that have been made by locating the recording instrument in his office. The instrument operates on two wires and a ground. The sender operates the contact at 0.05 foot of change in the water level, either up or down. This change is transmitted over two wires, one the falling stage, the other the rising stage to the recording instrument, where it in turn is marked upon a paper chart in the same manner as is the record from the other types of gages.

ROCKFORD'S NEW WATER WORKS[1]

By Rodney C. Wilson[2]

In presenting this paper I shall endeavor to describe, in a non-technical way, why and what Rockford is doing to increase its water supply.

For a number of years Rockford has had an inadequate water supply. Sprinkling has been partially eliminated each summer and no effort has been made to get larger industrial consumers.

In 1910, the city had an investigation of their water supply made by Messrs. Mead, Maury and Alvord, their findings being summarized in a complete and detailed report.

The only thing attempted to follow out suggestions, has been the installation of two electrically driven unit wells, one in the north end and another in the southeast end of town, and the laying of a few large mains.

In 1919, a bond issue was authorized and Messrs. Mead and Seastone, of Madison, Wis., were retained to design and construct the new water works. The question of deep wells or filtered river water was decided in favor of deep wells. The opinion was that it would be foolish to purify water artificially, with an element of human error creeping in, when an abundant supply of pure water could be had by drilling and at no greater expense.

The question of location was next decided on the west side of the city. The future growth of the city's population and distribution system, were taken into consideration, as well as the cost of the land.

In designing the new plant the thought throughout has been to plan for the future and to have adequate facilities for expanding and enlarging, and not to repeat the mistake of former years of having to relocate and practically to abandon the present water works, because the poor location prevented any possible expansion. This is readily evident when you realize that the old plant is on the

[1] Presented at the Illinois Section meeting, March 29, 1922.

[2] Superintendent, Water Department, Rockford, Ill.

bank of our beautiful Rock River, in the heart of the business district, and every pound of coal used has to be hauled by truck or wagons.

The construction of the new plant was started in June, 1920, with the building of a 5,000,000-gallon reservoir, of reinforced concrete, and possessing several novel features of design. The floor and the walls of this reservoir are built as one unit and the columns and roof as another. The expansion of the roof, with the sun beating down upon it, would be much greater than the walls, with the reservoir filled with water. This design eliminates the danger of the roof cracking the walls. To permit the movement of the roof on the walls, due to expansion and contraction, a greased, galvanized plate has been inserted on top of the walls.

As previously mentioned the water supply is from deep wells. The drilling of the first well was started in July, 1920, and at the present time we have three wells completed and the fourth one well under way. The wells, for the first 300 feet, are 14-inch bore and then, to the depth of 1600 feet, are of 12-inch diameter. The wells are cased with 15-inch steel pipe into rock, to a depth of 110 feet from the surface, at which point a cement joint is made. This effectively seals off the wells and prevents any ground water from seeping in. There are two underlying water bearing strata: one, St. Peters, which is at a depth of about 200 feet, and is about 150 feet thick, the other, the Potsdam Sandstone, which is beneath the St. Peters and separated from it by magnesium limestone. This magnesium limestone is about 250 feet thick in this locality. Our wells thus extend into the Potsdam Sandstone about 1000 feet. The capacity of each well is estimated at between 2,000,000 and 2,500,000 gallons per day. These wells are separated from each other about a city block and it is believed that pumping at this rate the level of the water in the wells will not be drawn down over a maximum of about 80 feet. The water now stands in the wells about 30 feet from the surface.

The pumping station building itself is an imposing structure, set back from the street about 90 feet, built of Chicago common brick, with raked joints in chocolate colored mortar, with a little sandstone trim. The pump room itself is about 60 x 114 feet, rising 40 feet above foundation; this height being necessary to permit the installation of a 10 and a 15 ton Whiting Crane. The right half of this building will contain a new 2500 cubic foot Laidlaw

Air Compressor and a 1500 cubic foot Ingersoll-Rand Air Compressor. The latter compressor is now in operation at the old plant, but will be moved some time this summer. This gives us a duplicate pumping outfit for the deep wells.

In pumping the wells an initial air pressure of about 100 pounds is carried and the air is conveyed through 6- and 8-inch Crane special coated pipe lines to the wells. The wells themselves will be equipped with an Indiana air lift, which will force the water up and into a so called booster chamber and from there into the reservoir through a 16-inch conduit. The piping is so arranged that any one or all of the wells may be pumped at the same time.

The left half of the building will contain a 15,000,000-gallon horizontal cross compound condensing snow pump and a 10,000,000-gallon pump of similar make. The latter pump is now doing duty at the old pumping station.

The 36-inch discharge, from the reservoir flows into a suction well just outside of the pump room. This suction well is 24 feet in diameter and has a valve chamber outside. The suction to the pumps is 30-inch. The pumps discharge into a 36-inch header, connecting with the 24-inch discharge line. This header is arranged to feed the city in two directions and permits the by-pass of either pump. It is our aim to have a Venturi recording meter set in this line, to permit an accurate measurement of the delivery.

Adjoining the pump room is the boiler room, which is 62 x 75 feet, and has an extreme height of about 70 feet, made necessary by the installation of coal bunkers, which we expect to have installed by the middle of June. These are steel bunkers, suspended on steel columns, and have a capacity of 450 tons of coal; they are divided into four pockets, one of which is for ashes. The coal will be conveyed from the track, at the rear of the building, through a concrete tunnel, and fed to the bunkers by a Link-Belt. The boiler equipment consists of three 300 h.p. Stirling boilers, equipped with the Jones Underfeed Automatic Stokers. The boiler feed water is softened by a Graver Corporation Water Softener, which uses lime and soda ash. The filtered water from this Softener goes to a reliance, open type, feed water heater and from there it is pumped into the boilers.

The plant is designed for efficient operation. The automatic stokers, the overhead bunkers and automatic scales and ash conveyors, cut the labor charges in the boiler room to a minimum.

The condensing engines, feed water heaters and steam traps, for turning all condensation into the hot well, permit efficient operation from a steam consumption standpoint.

When completed the cost will be approximately $750,000 which added to the previous investment of the city in water works and distribution system, makes a total investment for the city of about $2,000,000. This is about $30 per capita, and is, I believe, slightly under the average for cities throughout the United States.

We expect to have the plant tested out in May and it should be pumping and supplying the city with water this summer.

GROUND-WATER SUPPLIES FROM PRE-GLACIAL VALLEYS[1]

By W. D. P. Warren[2]

GENERAL

Ground-water supplies are generally found in pre-glacial valleys, and it is, therefore, of considerable importance to understand the methods of determining the location and boundaries of such valleys. It is the purpose of this article to discuss and emphasize the principles which govern the economical development of shallow ground water supplies and to point out the relation which deposits furnishing such supplies have to the pre-glacial valleys.

In Illinois, where there are more than six hundred cities and villages of less than 2000 population without a public water supply, and where many of the other cities are in need of additional supplies, it is a matter of vital importance to utilize all the resources which have been so generously provided by nature. It is with this thought in mind that it is proposed to show the value of water bearing deposits in the pre-glacial valleys, and the methods of developing these.

During the past five years, and to a certain extent during the past thirty years, the cities of Virden and Girard, located in Central Illinois, have endeavored to develop water from wells, and as the experience of these cities is somewhat typical, it may be of interest to point out the ease with which they finally discovered a water supply in a pre-glacial valley, after many years of tests and experiments elsewhere.

PRELIMINARY INVESTIGATIONS, VIRDEN AND GIRARD

Virden has a population of about 5000, and Girard about 2500, and as each had spent considerable money at various time in seeking a water supply from wells, it was finally decided last year to make surveys and estimates of reservoir sites with a view to the develop-

[1] Presented before the Illinois Section meeting, March 29, 1922.

[2] Of Holbrook, Warren and Andrew, Consulting Engineers, Decatur, Ill.

ment of a surface supply, suitable for both towns, inasmuch as they are only two and one-half miles apart.

At that time Virden had abandoned all hope of a supply from wells and Girard was testing a territory which had shown but slight promise of a well supply during former investigations.

Upon completion of preliminary surveys, plans and estimates of surface supplies, it was seen that unusual costs would be involved, due to the lack of a natural reservoir site, and therefore further consideration was again given to the possibility of a well supply, even though it might be located at some distance from the city.

As Virden had put down twelve to fifteen holes, the majority of them on one 40-acre tract, and had failed to secure a well supply, and as Girard had more recently put down ten or twelve holes, also with poor results, it was finally decided to consider a location about five miles south of Girard and nine miles south of Virden, early information regarding this site tending to show a remarkable supply of ground water available. Accordingly the investigation of a well supply was undertaken in this territory, the final result being the discovery of a pre-glacial valley filled with water-bearing sand and gravel, and fed from a water shed area of approximately one hundred square miles.

LOCATING PRE-GLACIAL VALLEY

There are several fundamental principles involved in the development of shallow ground-water supplies, and one of the most important of these was clearly stated by Hubbard and Kiersted in "Water Works Management and Maintenance," as follows, "No more water can be continuously taken out of the ground than goes into it." In other words, the extent of the water shed area which feeds the underground gravel bed is of vital importance.

With this principle in mind we had some difficulty in becoming interested in the development of wells at the site suggested, for a glimpse at the map showed only a few square miles of water shed area, with a prospect therefore of being able to develop a very limited supply.

As the reports of water found were positive, however, a conference was held with officials of the Standard Oil Company at Carlinville, Illinois, and substantially the following information was secured:

Mr. C. W. Clark, Assistant General Manager, stated that a year or so previously his company had undertaken to put down a modern

mine shaft there, that after going down some distance they encountered unusual quantities of sand and water, and that finally, after having pumped for days and after having spent approximately $200,000, they were absolutely forced to abandon the shaft due to the strong flow of water. Pumping did not lower the level of water over a few feet below the ground surface.

As this shaft was located in a rather flat prairie country it was difficult to account for such a flow. Mr. Clark kindly offered his files showing record of drill holes in that territory and it was possible to trace the source of the water. In fact, the information secured from these files, together with additional records of drillings from the State Geological Survey, afforded an opportunity to study the relation of the ground water to the pre-glacial valley which ordinarily could not have been done except by sinking a number of carefully located test wells.

A general outline map of this territory was prepared with streams, surface contours at 50-foot intervals, and sub-surface contours, or contours on the bottom of the glacial drift, at 50-foot intervals.

These were located by platting the elevation of the base of the glacial drift as determined by test holes, and the final result shows the pre-glacial valley of Macoupin Creek located north of Carlinville, underlying a flat prairie country, while the modern valley of Macoupin Greek is south of Carlinville, as is clearly shown by the cross-section, and is located at an elevation practically one hundred and forty feet higher than the pre-glacial valley, thus tending to cause the underground waters of Macoupin Creek to seek the pre-glacial valley.

It appears, from a study of the situation presented here, that the glacier in flowing to the south covered over the old valley, and since then the modern Creek has gradually cut its way to rock or shale at points south of Carlinville. The presence of unusual amounts of water in the pre-glacial valley to the west of Carlinville was noted by drillers, although all the holes shown were put down in a search for oil.

In the interpretation of the drill records and other data bearing on this development, much credit is due Mr. G. C. Habermeyer of the State Water Survey and Dr. M. M. Leighton of the State Geological Survey, both of Urbana.

In this connection, Mr. Habermeyer advised in part, as follows: "Report of water supply investigations for Virden and Girard,

dated February, 1922, is received and read with interest. That looks like an excellent job in tracing out old stream valleys."

Also under date of March 15th, Dr. Leighton advised as follows:

> I have gone over the evidence bearing on the question of an old pre-glacial valley in the vicinity south of (Girard) Nilwood. This evidence seems to be good and the existence of sand and gravel at the bottom of this valley, as tested by several wells, and the abundant supply which came from the shaft of the Standard Oil Company, all indicate that this is a favorable place to drill for a water supply.

In considering the vicinity of the Standard Oil shaft as a location for the development of a ground-water supply the following important facts and advantages should be clearly understood:

1. The percolating water that fills the sand and gravel deposit in the old pre-glacial valley, is supplied from a water shed area of one hundred square miles, an area sufficient to provide for a population of several hundred thousand.

2. Storage of the percolating water depends on the extent of the sand and gravel deposit in the pre-glacial valley, and in this case sufficient test holes have been put down to indicate ample storage.

Probably one-fourth to one-third of the volume of sand may be taken as the volume of water available, and from the data collected it is readily seen that the supply of water here is more than adequate. At some points the sand shows a depth of one hundred feet.

3. The longitudinal and transverse slope of the pre-glacial valley is such that maximum velocity of flow of water will be secured, in so far as the quality of sand will allow.

4. The quality of sand is such as to permit the development of water at a reasonable cost. In most deposits of this character, the sand varies in coarseness at different points in the valley, and the final location of wells and the type of screens and installation will depend somewhat on the quality of sand available. In the present case, the sand is of a quality to permit development of wells at a reasonable cost.

IMPORTANCE OF STUDIES

In the studies and investigations made over an extended period of years in the vicinity of Virden and Girard by various city councils under different engineers, it may be seen that little though was paid to the importance of locating the pre-glacial valley. Had a series

of holes been put down west of Girard or north of Virden, determining the location of the pre-glacial valley and the water shed area, much useless expense and delay might have been avoided.

As the situation stands today, there has been so much haphazard drilling through this territory that the people have little heart in any suggestion as to a more careful study near Girard or Virden, and, therefore, considering the positive information which we have regarding the supply near the Standard Oil shaft, it is thought that no further expense should be incurred in prospecting elsewhere.

A study of old pre-glacial valleys has shown that the present channels are often remote from the old, and this is fully borne out by the situation south of Girard.

A glance at the map will indicate the value of knowledge relative to the pre-glacial valley north of Carlinville, as that city may at some future date require an additional supply of water.

It is desired to point out here that a complete mineral analysis is of course essential before final adoption of any site. The point emphasized in this discussion, however, is the relation of the pre-glacial valley to well supplies, rather than a comparison of mineral qualities of underground and surface supplies.

The cities of Virden and Girard have not yet proceeded with the construction of a pumping plant at the site of the Standard Oil shaft, but they have secured positive information as to the existence of a remarkable water bearing deposit in their vicinity, information which they have sought for many years, and, as a result, they are a step nearer the final solution of their water supply problem.

COMPARISON WITH SURFACE REQUIREMENTS

It is generally understood that in developing a surface supply certain fundamental principles govern, and similar priniciples also govern in the development of a shallow ground water supply.

Briefly, the considerations which govern the development of impounding reservoirs are as follows:

1. Extent of water shed area
2. Rainfall
3. Run-off
4. Percolation
5. Storage available

For the development of a shallow ground-water supply, the principles which govern are as follows:

1. Extent of water shed area
2. Rainfall
3. Run-off
4. Percolation
5. Storage available

Comparison shows that the requirements are absolutely the same. And yet how few cities know and apply these principles? How many cities having wells know the area of the water shed from which they are supplied, and how many have knowledge of the available underground storage?

Hubbard and Kiersted point out the following considerations:

No more water can be continuously taken out of the ground than goes into it.

The yield of the ground-water is dependent upon the character and extent of the catchment area and depth of the saturated water-bearing material.

The velocity of flow of ground-water depends upon the character of material through which it must pass in gravitating from a higher to a lower level.

The stability of the ground-water supply depends upon the three considerations above stated as well as upon available ground storage at the point selected for developing the water supply.

Goodell, in his book "Water Works for Small Cities and Towns," also states this principle, as follows:

The amount of water that may be obtained from deep and shallow wells is so often over-estimated that it is necessary to call attention to the fact that the quantity available depends on the *same* conditions as the amount of surface water, that is, the extent of the catchment area, the rainfall, the proportion of the rainfall entering the ground and the capacity of the basin to hold ground water.

It may be contended that it is a rather difficult and expensive matter to determine the water shed area and the amount of underground storage. Possibly this is true, and yet does not the cost of a water works system require certain expense for investigation, and does not the planning of a works capable of fitting into any future scheme of development require thorough and careful study? In the development of a surface supply we do not accept a natural reservoir site without knowledge of the water shed area and the other factors which govern, and, as indicated by the above authorities, exactly the same principles should apply in the development of ground-water.

Again we must distinguish between the well supply developed from pre-glacial valleys and from sand and gravel deposits elsewhere in the drift. Such deposits in the drift are sometimes more difficult to define as to location and extent, and generally are more limited in volume. For this very reason they are more liable to failure unless thoroughly explored.

With these principles in mind it appears that the value of pumping tests, especially those limited to a few weeks or months have been over-estimated. Pumping tests, except to secure samples of water, are as a rule deceptive and unnecessary.

CONCLUSIONS

The investigation for a new or of an additional water supply should be conducted along broad lines, keeping constantly in mind that such investigations may be properly extended a distance of five, ten, twenty or more miles beyond the city limits. A few comparisons in cost may show that a well supply may be developed at distances not heretofore seriously considered. The present lower cost of cast iron pipe and the high cost of reservoir lands, are factors which will influence a final decision.

Keeping clearly in mind the fundamental principles which govern the development of a shallow ground water supply, and realizing the relation thereto of deposits in the pre-glacial valley, it will be of interest to consider proper methods of development. These may be briefly summarized as follows:

1. An examination of the extent of all possible water shed areas within reasonable distance. As a rough rule, we might say that a city of 2000 population may economically develop a well supply at a distance of not over five miles, while a city of 50,000 might economically develop a well supply at a distance of not over fifteen or twenty miles, depending on availability of natural reservoir sites, relative elevations, cost of land, etc. The advantages of a well supply, with low first cost and low operating cost, will justify extending our investigations over a wider field than generally considered necessary.

2. An examination of well records, test holes, borings and other data in the territory under consideration. Such records may often be secured from coal, oil or gas companies, local well drillers, and of most importance in this State, through the State Geological Survey at Urbana. Some such records are confidential, however, the portion relating to depth of glacial drift is not, and may generally be secured to be used in the investigation of a municipal supply.

3. A thorough study of all available records with a view to determining the dip of the rock or shale at base of glacial drift and the location of pre-glacial valley. This study should be made before the location of any additional drill holes is considered. Often the elevations as disclosed by the records of two or three old holes will indicate the direction of the pre-glacial valley, and a little further investigation should definitely establish its boundaries.

4. The application of knowledge obtained through above studies and the location of test holes in accordance therewith. Such test holes should furnish sufficient additional data to determine the possibilities of any site under consideration.

5. With complete and accurate data upon these principles, a conclusion may then be reached as to the value of such a supply, compared with a surface supply, and recommendations may be made regarding future developments with a full knowledge that all facts relating thereto have been properly cnnsidered and analyzed.

THE SCHOHARIE DEVELOPMENT OF THE CATSKILL WATER SYSTEM OF THE CITY OF NEW YORK[1]

By J. Waldo Smith[2]

There has been no time since 1832 when the municipality undertook to provide the adequate water supply, by the construction of the Old Croton dam and aqueduct, that the City of New York has not been engaged in developing increased sources of supply. During most of this period the old City of Brooklyn was also continuously extending its ground water supply on Long Island. The increase of population coupled with improvements in sanitary facilities have resulted in such a continuous increase in the use of water from year to year that there have been only short periods immediately following the introduction of a new source before the demand overtook the supply.

Population and consumption of water in New York City, 1870 to 1920

YEAR	POPULATION	CONSUMPTION GALLONS PER DAY	PER CAPITA CONSUMPTION GALLONS PER DAY
1870	1,478,103	97,700,000	64
1880	1,911,698	126,700,000	67
1890	2,507,414	195,400,000	78
1900	3,437,202	392,400,000	114
1910	4,766,883	528,500,000	111
1920	5,620,048	734,800,000	131

At the present time the City has under construction works to develop and utilize the waters of Schoharie creek as the second stage of the Catskill system. This source combined with the Esopus development already completed, will furnish about 600,000,000 gallons a day. This tremendous addition to the supply for the City will suffice, however, only to the year 1935 or very shortly thereafter, so that the Board of Estimate and Apportionment in

[1] Presented before the Philadelphia Convention, May 16, 1922.

[2] Formerly Chief Engineer, Board of Water Supply, New York, N. Y.

June of last year requested the Board of Water Supply to report on the sources available to meet future water supply requirements of the City.

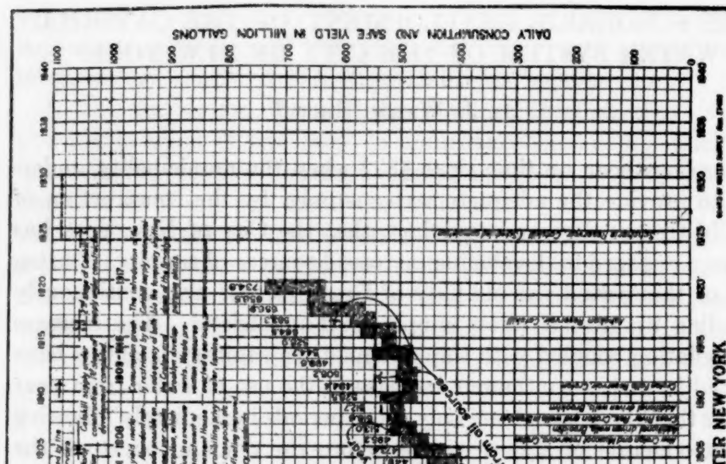


Fig. 1.

If we review the history of the Catskill system it is found to be merely repetition of previous experience in the development of the Croton system and of all large public works in general, as regards the time consumed in securing authorization and again in constructing

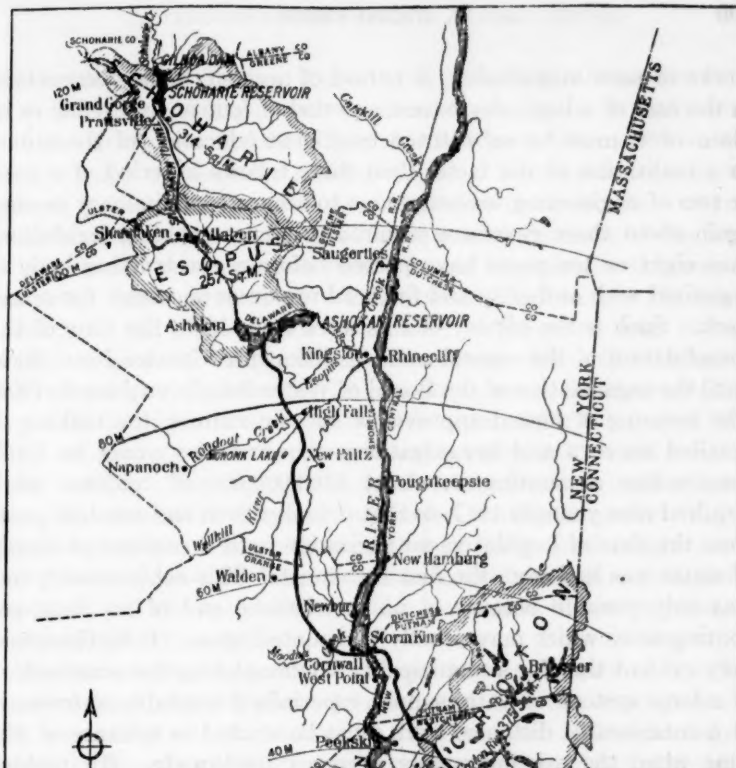


FIG. 2. CATSKILL WATER SUPPLY SYSTEM

Showing Schoharie and Esopus watersheds, line of the aqueduct, and their relation to the Croton and Ridgewood systems.

works of such magnitude. A period of necessity must occur which in the case of a large city covers a period of four or five years, or in place of it must be substituted intelligent education of the public to a realization of the facts; then there follows a period of a year or two of engineering investigations to secure a preliminary report; again about three years are required to secure enabling legislation; thus eight or ten years have passed before a constructing body is organized with authority and financial resources necessary for actual work. Such is the history of this work from 1898, the time of the consolidation of the several municipalities into Greater New York, until the organization of the Board of Water Supply on June 9, 1905. The securing of formal approval of specific sources, the making of detailed surveys and investigations, required two years to 1907; construction amounting to about $100,000,000 of contract work required nine years to 1917, so that it took eleven and one-half years from the time of Legislative authorization until a continuous supply of water was had from the first increment. This achievement, too, was only possible because of no interference and of no untoward contingencies which may usually be counted upon. It is, therefore, very evident that for a municipality contemplating the construction of a large system of water supply, especially if available sources are at a considerable distance, work must be started in advance of the time when the existing supply becomes inadequate. By making preliminary reconnaissance for future sources at this time, it is hoped to avoid some of the usual preliminary delays on the next supply.

The original plan for the Catskill system adopted in 1905 contemplated the development of four sources, the watersheds of the Esopus, Rondout, Schoharie and Catskill creeks, embracing practically the entire drainage area of the famous Catskill mountains, one hundred miles to the north of the City and some twenty miles and more west of the Hudson river.

The first stage included development of the Esopus creek by the construction of the Ashokan reservoir of 130,000,000,000 gallons capacity, this providing a considerable storage capacity for such of the other streams as should be subsequently developed; it also included the Catskill aqueduct of a capacity of not less than 500,000,000 gallons a day, Kensico reservoir holding about sixty days' supply located about thirty miles north of the City, Hill View reservoir holding about two days' supply located at the City line and acting as an equalizing reservoir, Silver Lake reservoir on Staten Island and the

full capacity distributing tunnel and pipe lines within the City. The first stage was put into permanent service in January 1917 and the draft from Ashokan reservoir has been 375 to 400 million gallons a day continuously since that time, a quantity 50,000,000,000 gallons in excess of the total flow of Esopus creek for the five year period. Such a heavy draft has been possible because of the large storage capacity of Ashokan reservoir and because the Croton and the Long Island sources were held partially in reserve. It brings forcibly to our attention the desirability of providing large storage on any large water development. The storage capacity of Ashokan reservoir, if provided for the Esopus alone, would be equivalent to the total flow in an average year as determined for the period 1907 to date, during which there was no excessively wet period such as 1901 to 1903. The draft of the total stream flow has been of great financial value to the City as it permitted, during the period 1917 to date, of placing in reserve the Long Island Ridgewood supply which is obtained by pumping from the outwash glacial sands at just above sea-level, and the coal bills for which amounted before the war to about $1,300,000 each year.

The investigations conducted during the construction of the first stage of the Catskill system demonstrated that the most desirable and economical source from which to secure the additional supply necessary to utilize the full aqueduct capacity was Schoharie creek, the drainage basin of which is adjacent to that of Esopus creek on the north. It has a general elevation somewhat higher than that of Esopus creek, while the character of the shed is very similar and the water is of the same excellent quality. The water is soft, as there are no limestone outcrops, the bed-rocks being entirely of shale and sandstone. The Schoharie and Esopus watersheds are for the most part wild and mountainous forest lands. The rainfall is abundant and quickly finds its way to the water courses. There are generally large freshets in the spring from the melting of heavy snows, with a complementary summer flow, which, for several months in most years is negligible in amount. Of the average 47 inches depth of rainfall in a year on the Esopus watershed, 29.5 inches (63 per cent) appears as stream flow, while the Schoharie, with only 39.5 inches of rainfall, yields 27.2 (69 per cent) as stream flow. Compared with these, from published data the Croton yields 22.4 inches of stream flow and the Wachusett watershed, of the Boston supply, yields but 21.3 inches of stream flow, on the average.

These watersheds are dotted, here and there, by small villages which accommodate a considerable number of summer visitors, and there are also several hundreds of farm houses along the valleys and cloves. A sanitary survey shows a permanent population on the Esopus of 5239 with a summer addition of 5674, equivalent to a total density of 43 per square mile, and on the Schoharie, permanent 8792, summer 6000; total density 48. There is no probability of an appreciable increase of population, as the census figures indicate no increase in the population of these townships for several decades; in many cases there is a decrease.

Much attention is paid to the pollution of tributary streams, especially near communities where there is a considerable influx of summer visitors. The co-operation of communities has been obtained and the sanitary conditions of hundreds of premises are being improved.

As at Ashokan and Kensico reservoirs a marginal strip of land nearly 1000 feet in width has been taken around the reservoir. This strip of land will be to a large extent cleared of undesirable growth and dead wood and reforested with evergreen trees. This will tend to prevent erosion of the shores and gives such control of the ground adjacent to the reservoir that contamination and pollution may be avoided.

The works under construction are primarily a masonry and dike dam about 160 feet high, with crest at Elevation 1130, located at the village of Gilboa in Schoharie County, forming a reservoir of 20,000-000,000 gallons available capacity, and an 18.1 mile tunnel therefrom, of about 600,000,000 gallons a day capacity, through the main dividing mountain ridge, known as the Shandaken Mountains. The southerly end of the tunnel will discharge into the Esopus creek from which point the water will follow the natural bed of the Esopus into Ashokan reservoir, where it will be available for the Catskill aqueduct.

The Gilboa dam on Schoharie creek is about 40 miles northwest of the headworks of the aqueduct at Ashokan reservoir and extends the system to an overall length of about 160 miles to the terminal reservoir on Staten Island. The estimated completed cost of the Catskill system for the works completed or under way is $180,549,360 and the total disbursements to April 1, 1922 amount to $151,784,843. The final cost by structures has been estimated as follows:

Estimated final cost of Catskill system for works completed or under way

92 Miles Aqueduct—Ashokan Reservoir to City Line...	$72,108,332
Ashokan Reservoir—130,400,000,000 gallons capacity....	31,067,417
Kensico Reservoir—30,573,000,000 gallons capacity	15,170,538
Hill View Reservoir—900,000,000 gallons capacity	5,806,280
18.1 miles City Tunnel—Full Capacity..................	23,267,530
12.6 miles 66-inch Steel and 48-inch C. I. Conduit.........	1,500,913
2.8 miles 36-inch Narrows siphon and 48-inch C. I. Pipe	1,277,157
Silver Lake Reservoir—435,000,000 gallons capacity.....	1,128,817
Schoharie Reservoir—20,000,000,000 gallons capacity....	14,092,773
18.1 miles Shandaken tunnel to Esopus creek...........	14,640,152
Investigations of other watersheds.....................	489,452
Total....................................	$180,549,360

With water from Schoharie available during 1924 the City will have a total municipal supply of approximately 1,000,000,000 gallons a day. Several private water companies now furnish an aggregate of about 40 million gallons of water a day to some of the outlying districts of Brooklyn, but as these are being taken over by the City as rapidly as legal procedure will allow and will be discontinued, they are not included in the following summary:

Water supply sources of New York City on completion of Schoharie development

	DRAINAGE AREA IN SQUARE MILES	AVAILABLE STORAGE WITH FLASH-BOARDS IN MILLION GALLONS	RATED YIELD IN MILLION GALLONS PER DAY
The Catskill system:			
Ashokan reservoir..........................	257	130,400	300
Schoharie reservoir........................	314	20,000	300
Catskill Mountain sources.................	571	150,400	600
Kensico reservoir..........................	22	30,573	20
Byram and Wampus reservoirs..............		1,012	
Total Catskill system......................	593	181,985	620
The Croton System:			
16 reservoirs and ponds....................	375	104,443	315
Long Island System:			
1 reservoir, 12 ponds and ground water pumped supply............................	168	1,100	139
Total municipal sources..................	1,136	287,528	1,074

Preliminary work and acquisition of property. The original plan of 1905 contemplated a small reservoir on Schoharie creek at a site known as Pratts Rocks where the tunnel to the Esopus creek was only 10 miles in length. The dam site was fairly satisfactory, but with the stream measurements showing the flow to be larger than previously estimated and dams on the other streams, Rondout and Catskill creeks, appearing to be more expensive than originally estimated, it was found to be economical and otherwise desirable to complete the supply from the Schoharie alone by constructing the dam further downstream. During 1914 and 1915 work was concentrated on searching for a favorable dam site, working downstream until sub-surface investigations were made at five possible sites on the six miles of the creek between Pratts Rocks and the final site chosen at Gilboa. The amended plan submitted in December of 1915 was finally authorized in June of 1916. The land taking surveys were begun in July 1916 and detailed sub-surface investigations by diamond core-borings for the tunnel location and for the dam foundation were prosecuted in 1916 and 1917. This boring work was at first concentrated on the tunnel.

While the Board of Water Supply has in its engineering corps many men experienced in diamond-drill core-boring work, the equipment and personnel for this class of work are limited, they not being primarily engaged in boring work, so it has been found to be both far more expeditious and economical to do this work under boring agreements covering some 5000 to 10,000 linear feet of borings each. At least four of the most expert and fully equipped concerns specializing in this work are requested to submit tenders for the work in hand and the agreement is awarded to the one submitting the most advantageous tender. Such concerns are able to put as many rigs as desired in operation very quickly. Their men being expert and engaged solely in this class of work, delays caused by lost tools, and the many difficulties encountered below ground and which are often aggravated by lack of experience or skill, become negligible. Following is a summary of the core-boring work for the Schoharie structures:

Cost of Schoharie core-borings

Dam sites, 318 Borings, 31,996.4 feet	$95,030.60
Dam sites, other sub-surface work	9,715.52
Tunnel, 154 Borings, 18,356.4 feet	43,129.24
Total, 472 Borings, 50,352.8 feet	$147,875.36

The property has been acquired by condemnation, as provided by the special act under which the Board is operating, Chapter 724, Laws of 1905. There is a provision by which title becomes vested in The City at the time the Commissioners of Appraisal file their oaths of office and upon The City paying one-half the assessed valuation. The City became vested with the real estate, 80 acres fee, 49 acres easement, total 129 acres for the tunnel and shaft sites, on May 25, 1917, and that for the reservoir, 2372 acres fee, with 2 acres road easements, on November 24, 1917, aggregating 2503 acres. The preliminary work of definite location and surveying, mapping and formalities of securing the property consumed about a year and a half from the date of the final approval of the project.

Water power claims on the Esopus are still on trial and some of those on the Schoharie have not yet come to trial. All claims of damage are tried before Commissioners of Appraisal in the same manner. The awards of the Commissioners of Appraisal are confirmed by an order of the Supreme Court in Special Term for the district in which the property is situated. The City is represented by the Corporation Counsel, and this Board also maintains a small engineering force assigned as a Bureau of Claims to collect information regarding all claims and to assist the Corporation Counsel on trial of them. There are several commissions, as it is the policy of the Court to have the taking so divided into sections that a commission may reach an award on the matters in one section or group of parcels within one year.

THE GILBOA DAM

At the Gilboa dam site the bed rock is at or near the surface on the easterly side and in the bottom of the present stream bed, while the westerly bank is composed of a very stiff impervious clay. The rock bed of the creek at the dam site is at Elevation 990 feet above sea level. Upstream from the dam the bottom of the preglacial gorge has been developed by core borings and found to be at Elevation 850, essentially parallel to the dam, and there also intersecting the present stream bed from where it takes a long swing under the clay foot hills and crosses the dam site at an undetermined distance of some 1500 feet or more under the hill to the west of the present stream bed. The floor of the preglacial gorge at the point explored is seamy sandstone at about Elevation 850 and the overburden is in general impervious and consists of fine red sand and

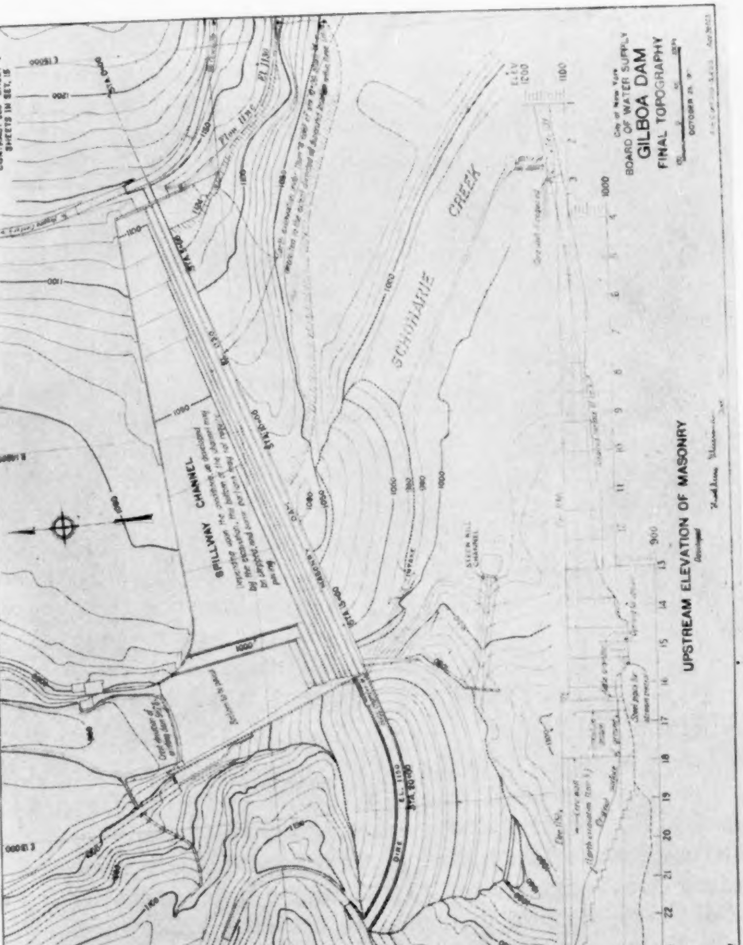

CONTRACT 203 SHEET 6 SHEETS IN SET 15
City of New York
BOARD OF WATER SUPPLY
GILBOA DAM
FINAL TOPOGRAPHY
SCHOHARIE
CREEK
SPILLWAY CHANNEL
UPSTREAM ELEVATION OF MASONRY
ELEV
1200
1100
1000
900

FIG. 3

clay, with beds of red and blue clay and occasional pockets of gravel. None of the other possible dam sites investigated showed a combination of conditions as favorable as that at Gilboa. In general, at the other sites, one side or the other of the valley was composed, in considerable part, of pervious material, and at none of them was the preglacial gorge of the stream so completely filled and deeply covered with tight and impervious material.

Contract 203, for the Gilboa dam and appurtenances, was awarded on June 20, 1919 to the Hugh Nawn Contracting Company, 82 Savin Street, Roxbury, Mass. for $6,819,910 based upon contract quantities and unit prices. The contract time for completion is 66 months. To April 15, 1922, the gross estimates amount to $1,352,424, or 20 per cent completed.

The dam is composed of two parts—an overfall masonry section about 1324 feet in length, having the crest at Elevation 1130 feet above sea-level, a maximum height of 160 feet, a width of 158 feet at the base and an earth dike section about 700 feet long with core-wall. The work also includes the construction of a spillway channel and appurtenant structures, stream control works for Schoharie creek and the Steen Kill, and about three miles of substituted new highways.

Masonry section. The overfall portion of the dam is founded on solid rock and will be constructed of cyclopean masonry consisting of large stones buried in concrete.

The Schoharie is known as a flashy stream under ordinary conditions. Not only does the stream rise very rapidly in the summer time but the rapid melting of the heavy snows brings flood conditions each spring, while perhaps once in a generation there occurs a real freshet, from which the natives reckon the ordinary happenings of life. These conditions led to the abandonment of a roadway or bridge over the dam and to the design of the masonry section as an unobstructed weir, the crest length of which is 1324 feet. A wide spillway channel along the base of the dam is provided leading to the present gorge, and the downstream face of the dam will be constructed in large steps.

All exposed masonry of the dam and wing walls will be faced with natural bluestone, a very dense and durable sandstone which has an established record of durability, and which is readily obtained from quarries developed near the site. The overfall corners of each step will be of the largest possible stones set on edge and thoroughly

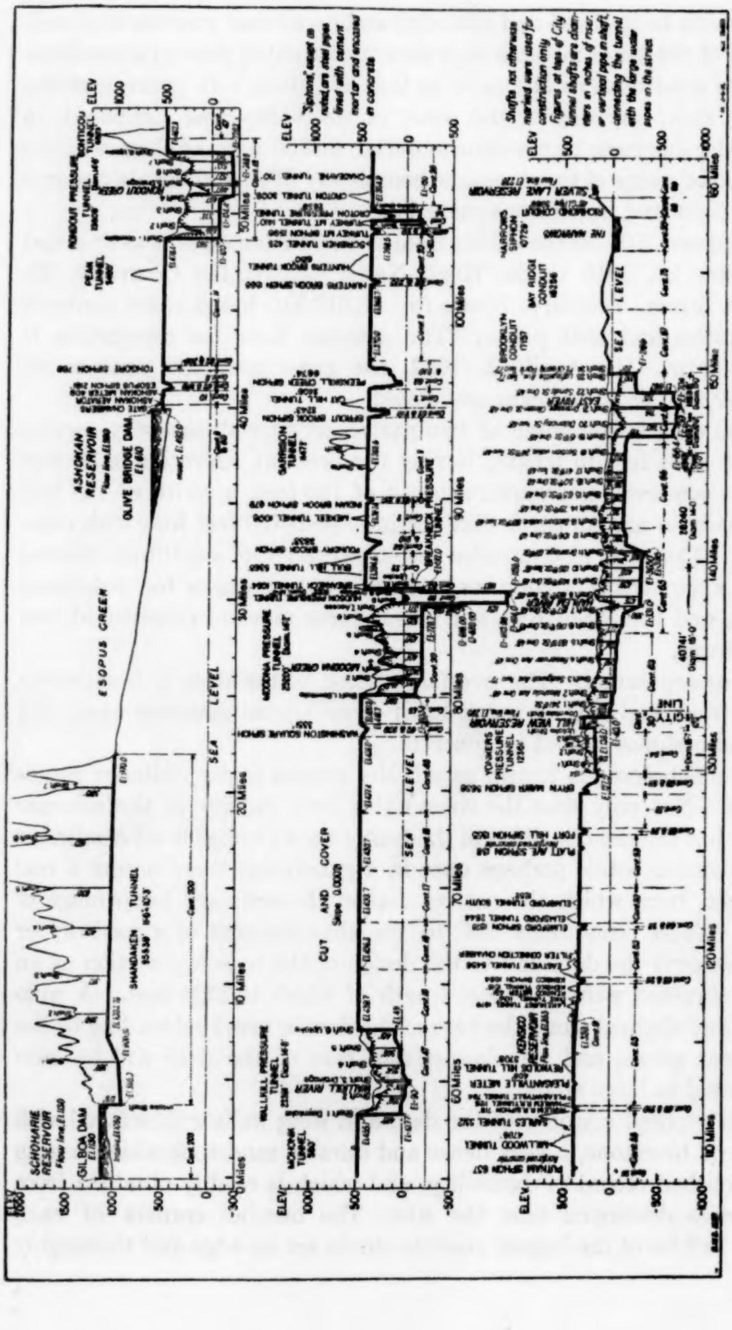


FIG. 4. PROFILE OF CATSKILL WATER SUPPLY SYSTEM FROM GILBOA DAM TO SILVER LAKE TERMINAL RESERVOIR

Showing elevations of the reservoirs and the different parts of the aqueduct

anchored. The stone facing of exposed masonry has been found to be desirable in that locality where the temperature ranges from 20°F. below zero in the winter to 102°F. in the summer and perhaps to 120°F. or more in the sun. The destructive agencies are particularly severe at the surface of the concrete in massive work where the surface is subjected to continuous atmospheric changes and where at the same time the interior maintains comparatively more uniform conditions of moisture and temperature.

Models of the Gilboa dam. Experiments were made in the field during 1919 and 1920 with small-scale models of the dam: first, to determine an economical size of spillway channel necessary to carry off the probable maximum flood flows; and second, to determine a stepped weir section which will effectively diminish the velocity of the overfall and cause the water to strike all steps, thus eliminating direct falls greater than the depth of one step. Modifications of the structure near the crest were devised and a final cross-section of the dam was decided upon. The models were built on scales of 1:50, 1:20 and 1:8. These experiments and the attendant studies showed that while the results obtained with the several scale models differed somewhat, there was, nevertheless, sufficient similarity to warrant the assumption that comparable flows over the dam will give results which will reasonably accord with those observed on the models.

Stream control. The flow of Schoharie creek was diverted during the early construction period through two 9-foot steel pipes carried across the dam site. These pipes were made of $\frac{7}{16}$-inch plate and were received on the ground in approximately 7-foot lengths of half section. They were supported every 30 feet on concrete piers. Working space for putting in the foundation of the dam within the limits of the creek was secured by building coffer-dams across the stream at the ends of the steel pipes at distances of 100 feet upstream and 190 feet downstream from the crest line of the dam. The rainfall for the season of 1920 during which this work was done exceeded that of any year since 1907 and several floods of unusual magnitude for the time of their occurrence caused considerable delays. During the season of 1921, the stream flow conditions were favorable and operations were advanced sufficiently on the river section to divert the stream through the opening left in the dam, so that the coffer-dams were

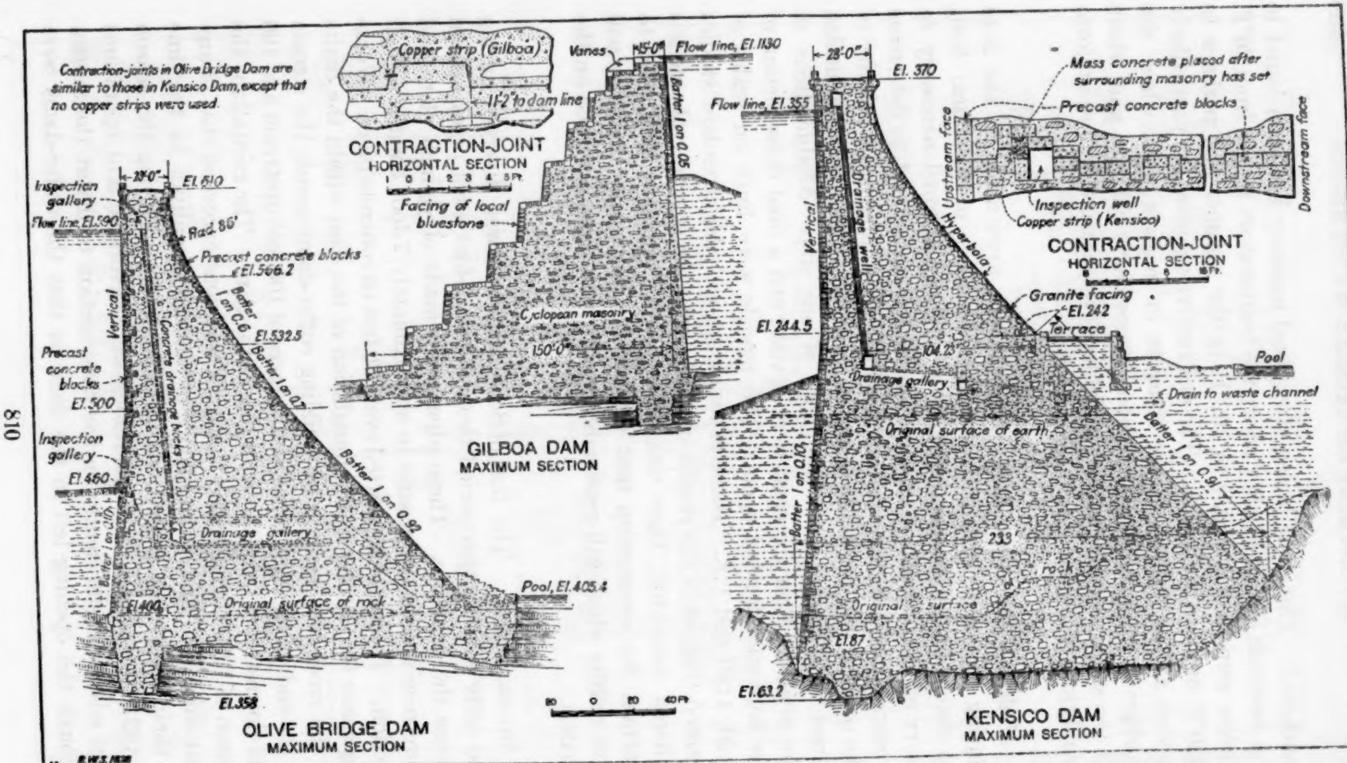


Fig. 5. Cross-sections of the Principal Masonry Dams of the Catskill Water Supply System

breached in December 1921 and the steel pipes dismantled. The opening through the dam is 44 feet wide and 30 feet high to the springing line of a 22-foot radius arch. Observations of flood flows through the stream-control opening in Ashokan dam, which had a straight-away opening with no bell-mouth, showed the water at the downstream end to be at about half depth. Profiting by that experience, the upstream end of the opening through the Gilboa dam is bell-mouthed to the extent of 10 feet on each side and top, the bevel running out to the above dimensions at 45 feet from the face.

Excavation of foundation. Earth excavation within the limits of the dam and spillway channel is made with steam shovels and delivered to the blanket fill by dinkey trains.

Rock excavation was started at the gorge and extended up the hill. A sump was excavated downstream from the dam, then a trench 10 feet in width was excavated normally across the entire width of the foundation by shallow drilling and light charges of powder, and the excavation was then extended from the faces of this trench in both directions on the main area. The rock was removed in two or three courses, a total average depth of 6 feet being removed for the full width of the dam from the portion thus far completed.

Channelers were installed for making the face cuts of the cut-off, with Ingersoll-Rand electric-air swing-back track machines. After considerable experimentation, it was found that these machines equipped with Z-bits, each made up of three pieces of 2-inch by 1-inch "Black Diamond." steel, gave excellent results. Sullivan air machine channelers were also installed after unsuccessful experiments had been made with a quarry-bar outfit. The cut-off trench is being excavated to a 20-foot top width, with its near edge coincident with the dam line. An 18-inch inset is made for the channel cuts which vary in depth from 4 to $6\frac{1}{2}$ feet. The total depth of the trench averages 20 feet for the portion now completed, under the highest part of the dam.

Grouting the foundation. In order to control the water in the cut-off trench, a line of diamond-drill holes, $2\frac{1}{16}$ inches in diameter spaced $2\frac{1}{2}$ feet on centers, was drilled on a line five feet upstream from the upstream edge of the cut-off trench; these holes were drilled at an angle of $22\frac{1}{2}°$ with the vertical, with varying depths between 40 and 50

FIG. 6. GENERAL VIEW OF THE GILBOA DAM SITE BEFORE CONSTRUCTION WAS BEGUN

feet. Artesian flow was encountered in seven of the various holes between Elevations 912 and 942 amounting to 100 gallons a minute, the bottom of the cut-off trench here being at El. 949. When the artesian flow began from a hole the leaks from the side-walls in the vicinity ceased. All holes were cleaned with a stream of water escaping at 125 pounds pressure from small holes in a pipe which was lowered and raised from the top to the bottom. Eighteen of these diamond-drill holes have been completed. In order to grout the foundation, 2-inch pipes were sealed into these holes and extended as the masonry was brought up. Leakage through seams was collected in wells and conducted to a longitudinal 4-inch pipe extending along the floor of the cut-off and carried the accumulated flow from the drill holes and wells, and seams in the rock face were calked and pipes set so that they could be grouted at a future date. Further grouting was also necessary throughout the bottom of a 76-foot section, where thirty-two grout pipes were set, and later, when sufficient volume of masonry had been placed, were grouted, apparently with good results; a total of 213 cubic feet of grout was used; each batch contained 23 gallons of water to one bag of cement, being changed to $12\frac{1}{2}$ gallons per bag to finish the hole. Other sections will be similarly treated as the foundation work progresses.

Pressure tests at the Gilboa dam site. Pressure tests were made to locate rock seams, to form an idea of their connection with one another and to find their approximate carrying capacity when subjected to a pressure equal to that which would result from a height of ten feet of water over the crest of the dam. The tests showed that in general there is considerable leakage in the upper portion of the holes and near the surface, through both horizontal and vertical seams, the number of seams decreasing with the depth. Vertical seams are frequent, extending in all directions, being in general continuous only for short distances, and the blocks between these seams overlie or underlie adjoining blocks, binding the whole mass together. No well defined horizontal leakage planes extending over the entire area were observable, though responses were obtained in some cases between holes four hundred feet apart. Seams are found both in shale and in the sandstone, although the more clearly defined seams are in the sandstone. From a study of these results tentative depths for the cut-off trench were determined and the location and depths of projected grout holes fixed.

FIG. 6. GENERAL VIEW OF THE GILBOA DAM SITE BEFORE CONSTRUCTION WAS BEGUN

Fig. 7. General View Showing Three Models of Tentatively Accepted Section of Gilboa Dam, Built to Scales 1:8, 1:20 and 1:50

The rock appears to be in a state of some internal stress, as when the channeler cuts have been made and the machine had passed on and later returned it was found that the channeler bit could not be inserted in the old slot. Also, horizontal off-sets, the largest having a maximum overhang of one-eighth inch, have been observed to take place at bedding planes when the rock in the cut-off trench was removed. The same peculiar behavior of the rock was noted when tightening up the bottom by barring and wedging as ordinarily in sandstone rocks when a wedge is driven in a seam a flat slab can be removed, but in this rock which is exceedingly brittle, it breaks with a concave breakage and frequently loose pieces are bound in.

Plant. A brief description of the plant in use is as follows:

A power line from the Intake of the Shandaken tunnel to Gilboa delivers energy at 33,000 volts to the transformers outside the compressor plant, at which point it is stepped down to 2300 volts. Near the site of the dam it is again stepped down to 440 volts, at which voltage the wires are carried to the different parts of the work, furnishing light and power to operate the electrical equipment.

In addition to electricity, compressed air is used to a certain extent, principally for operating drills, both at the dam and at the quarries and is furnished by a compressor plant from which a 4-inch air-line runs to the different parts of the work. Face stone, edge stones and plums for the cyclopean masonry for the dam are quarried by stone-cutters from the Riverside quarry which is located a short distance below the site. The stone is of excellent quality "bluestone" with blocks heavier than the usual run of stone in the vicinity. They are delivered to the dam by truck and are handled by the main cableway of 1900-foot span and 10 tons capacity and by four steel derricks having 100-foot booms now in place. Plums for the cyclopean masonry are also secured from the excavations.

The stone crushing plant at Stevens Mountain quarry is operated entirely by electricity and has a capacity of 150 cubic yards per hour. The plant includes a Traylor "Bull dog" jaw crusher, with 42-inch x 48-inch opening, a No. 16 Traylor gyratory crusher, and a No. 5 Traylor gyratory crusher, a belt conveyor 220 feet long, and a 90-foot boom conveyor, screens, etc. The storage pile is over a tunnel, through which 2-yard cars are drawn by hoist engine to bins which subsequently discharge the stone to a tramway. This tramway, 3670 feet long, delivers the crushed stone to a No. 5 Austin

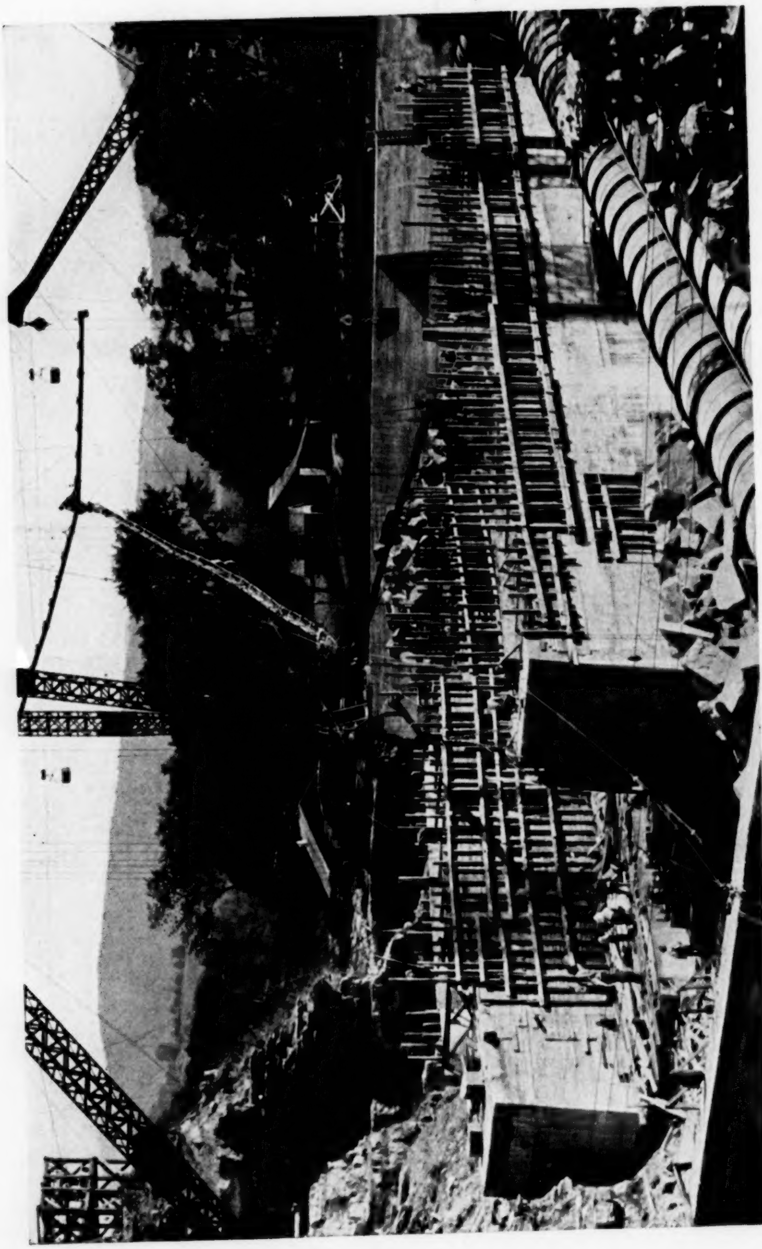


FIG. 8. GILBOA DAM UNDER CONSTRUCTION

Showing up-stream and down-stream cofferdams, 9 foot steel pipes for temporary stream control at left and partially completed permanent stream control at right. Chutes delivering concrete are also shown.

crusher, from which the stone is delivered to a belt conveyor carrying the stone to storage bins over the central concrete mixing plant at the dam. The tramway is operated at a speed of 500 feet per minute and has thirty-two 1-yard buckets spaced 250 feet apart. The cable is supported at the terminals and by ten intermediate towers of an average height of 22 feet.

Sand is delivered to a sand washing plant by a narrow-gage railroad. The washed sand is conveyed from the washer to the main concrete mixing plant by a tramway, 560 feet long, carrying two $1\frac{1}{4}$-yard buckets, operated at a speed of 500 feet per minute; here it is automatically dumped into a bin directly over the mixer. This cable is supported at the terminals and by one intermediate tower.

Cement is delivered from a storehouse at a rate of 6 bags every 48 seconds, by a 3300-foot tramway. This cable is supported at the terminals and by ten intermediate towers of an average height of 22 feet.

The main mixing plant consists of an electrically driven 2-yard Lakewood drum mixer fed directly from overhead stone and sand bins. The mixer dumps into elevator buckets operated by electric hoist drums which raise the concrete to the top of the 135-foot distributing tower, where the buckets automatically dump into a hopper. The hopper feeds directly into steel chutes which are suspended from a cable of 430-foot span swung between the elevator-tower and a 168-foot booster tower located across the site. The chutes were last year placed on a 1 to $2\frac{3}{4}$ slope and deliver directly to the dam. Some modifications of the chute system are under way.

Masonry. The cyclopean masonry will be carried up in sections of about 75 feet between contraction joints. Three such sections have been well started in the river portion, the central one including the stream-control conduit and another the steel control pipes. Facing stones were, in general, carried up ahead of the concrete, and so served as forms. Bulkhead forms were of rough lumber and contraction-joint forms of dressed lumber. Only about 10 to 12 per cent of large stone went into the masonry. In the Ashokan dam and Kensico dam, consistent effort was made to secure thirty per cent of large stone in the cyclopean masonry and 25 and 27 per cent, respectively, was attained. The concrete mix has been 1:2.52:5.04 by volume of cement, local sand and crushed stone, but this is varied as far as 1:2.0:5.25 when the sand runs very fine.

Showing up-stream and down-stream cofferdams, 9 foot steel pipes for temporary stream control at left and partially completed permanent stream control at right. Chutes delivering concrete are also shown.

In the matter of payment for cyclopean masonry the provisions of the Gilboa dam contract differ from previous practice in that the contractor is paid the unit price per cubic yard of cyclopean masonry and also for 1.1 barrels of cement per cubic yard of cyclopean masonry. It is also provided that the concrete going into the cyclopean masonry shall contain not less than 1.4 barrels of cement per cubic yard. In this manner, the usual bone of contention, the percentage of large stone going in, is avoided. Under this provision should less large stone be used the contractor does so at the cost to him of the extra cement used.

Contraction joints are spaced about 75 feet apart for the full length of the masonry portion. They are constructed as vertical panels or rabbets 12 inches deep and 18 or 20 feet wide along the joint, the edge of the rabbet having a 2-inch bevel to allow for the draw without breaking the corners. A vertical copper strip $\frac{1}{16}$ inch thick by 7 inches wide is cast into the edge of and across the joint of a special 4-foot panel, of 16-inch depth about 15 feet from the upstream face of the dam to serve as a water stop.

Dike and transition section. The earth dike and transition portion are at an elevation 20 feet higher than the weir crest and together are 700 feet in length.

The earth dike is of conventional design with concrete core wall. The core wall is 4 feet thick at the top and has a uniform batter of 1 foot horizontal to 20 feet vertical, both front and back. The embankment is compacted in 4-inch layers, has heavy stone paving for the full height of the water slope and the downstream slope will be covered with a layer of clean rock fragments.

The transition from the masonry stepped portion to the core wall is made in a length of 162 feet. At the junction with the stepped section is a heavy retaining wall extending at right angles to the dam on the downstream side to intercept the downstream earth slope and, being located along the westerly side of the present stream gorge, it will serve to divert flood waters coming down the spillway channel. There is another wing wall extending upstream to intercept the earth slope on that side. A gate-chamber in the transition section will contain 30-inch hydraulically operated gate valves in duplicate of each of two lines into which the blow-off conduit is here divided for the purpose of control.

THE SHANDAKEN TUNNEL

The Shandaken tunnel, 95,740 feet or 18.1 miles in length, is the longest tunnel in the world for any purpose. It is slightly longer than the City tunnel of the Catskill aqueduct. It is horse-shoe in section and concrete lined, with dimensions of 11 feet 6 inches in height by 10 feet 3 inches in width, and has a uniform slope of 4.4 feet per mile, except for the northerly 3½ miles, which is depressed, making that portion a pressure tunnel. The bottom of the intake channel cut is at Elevation 1050 above sea level and the sill of the outlet works is at Elevation 970. Seven intermediate shafts are provided, the aggregate depth of shaft being 3238 linear feet, and the maximum depth of a single shaft is 630 feet. The minimum distance between shafts is 1.3 miles and the maximum 2.7 miles.

The carrying capacity of the tunnel with the reservoir at full flow line, Elevation 1130, is estimated to be 600 million gallons a day. This is about double the average supply to be obtained from the Schoharie, but is required because the Schoharie reservoir will have a comparatively small capacity, more storage for Schoharie water being provided in Ashokan reservoir than on the Schoharie itself. In times of plenty the water will be rushed through to the Ashokan reservoir and at some periods there will be no flow through the Shandaken tunnel.

The tunnel line through the mountains is accessible from the Grand Gorge station of the Ulster and Delaware railroad, which is 4 miles from the Intake shaft at the northerly end of the tunnel, and from the Shandaken station of the same railroad which is 2 miles from the Outlet portal at the southerly end of the tunnel. Transportation by automobile is rather difficult in the summer and fall seasons, while in the winter and spring the country roads are impassable for considerable periods.

Sub-surface investigations. The locations of the tunnel Intake and Outlet were controlled within narrow limits by the situation of the dam at the northerly end and by the elevation of the Esopus creek bed at the southerly end. Likewise the location of the tunnel was controlled by the situation of the low points in the topography where the tunnel grade could be reached through shafts of reasonable depths. Two possible locations were investigated for the tunnel Intake and adjacent tunnel resulting in the placing of the Intake at the southerly edge of the reservoir and three and three-quarters miles above the dam.

At the southerly end, artesian flows were encountered in several borings, causing the relocation of the outlet works at Esopus creek and of the adjacent tunnel. The character of the rock was also investigated at all the shaft sites and their detailed situation established.

Contract 200. Progress. This contract for the construction of the tunnel and appurtenances was awarded on November 9, 1917, to the Degnon Contracting Company of New York City. The contract was assigned to the Shandaken Tunnel Corporation, 120 Broadway, New York City, on November 10, 1920. The estimated cost is $12,138,738 and to April 1, 1922 the gross estimates amount to $6,768,025 or 55.7 per cent completed.

The first heading was holed through on April 1, 1922 between Shafts 4 and 5, and concreting operations are started in this portion. The earlier stages of construction were affected by the economic and labor conditions brought about by the World War, but in spite of these difficulties good progress has been made. The excavation and lining of the shafts were done in 1918 and 1919, and on April 1, 1922, there had been excavated 76,000 linear feet, or 86 per cent of the tunnel. For several successive months, upward of 5,000 linear feet of tunnel has been excavated. The maximum progress made on the excavation of the tunnel may be stated as follows:

	feet
Maximum monthly excavation in 12 headings	5,979
Maximum weekly excavation in 12 headings	1,430
Maximum monthly excavation in 1 heading	611
Maximum weekly excavation in 1 heading	154

The tunnel intake works. The Intake chamber is to be constructed as a sub-structure 42 x 78 feet over the Intake shaft. The excavation for the chamber is taken out as a part of the deep side-hill rock cut of the Intake channel, the sill elevation being at the same elevation as the channel, Elevation 1015.

Within the chamber the shaft is extended up to the floor of the chamber, Elevation 1145, as a reinforced concrete cylinder having an inside diameter of 14 feet, the same diameter as the shaft, and with a wall of 4 feet thickness. This extended shaft head forms the draft tube for the tunnel shaft, there being eight 3-foot x 7-foot sluice gates built therein, six with sills at Elevation 1070 arranged equidistant around the periphery, and two with sills at Elevation 1050.

There is a clear space of 7 feet surrounding the shaft head except between it and the front wall of the chamber, where the space is enlarged to 16 feet radial width. The enlargement facilitates the circulation of the water after it enters the chamber through two 12½-foot x 25-foot rectangular openings at the bottom of the front wall of the chamber. Rack bar grilles are built outside the chamber in front of the openings for the entire width of the channel in the form of the roof and side of a "lean-to." A venturi meter is being constructed vertically, well down in the shaft, with the observation piping leading up to the chamber floor. There will be a superstructure over the chamber containing the gate operating mechanisms, a machine shop and the keeper's residence. As at the dam all exposed masonry will be faced with natural stone.

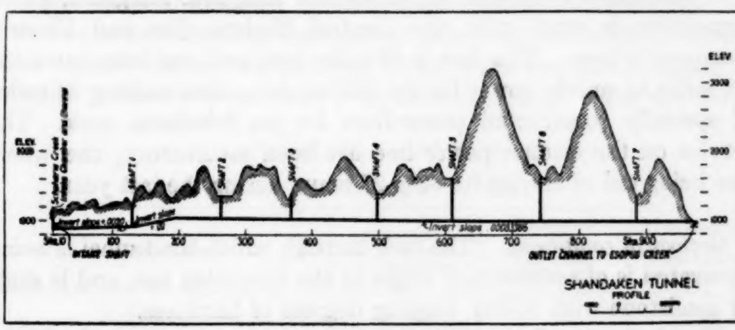


FIG. 9

Shaft sinking. The shafts were put down during 1918 and 1919. Only temporary shaft sinking outfits were used. The seven shafts and the Intake shaft are all circular shafts, 14 feet in inside diameter, and lined with concrete, of the standard design developed on the Catskill work. They will be covered with gratings to allow the escape of entrained air and for entrance to the tunnel.

In sinking all the shafts, earth was encountered for the upper portion, the maximum depth at any shaft being only 18 feet. At a few places water was struck in small quantities of 25 to 50 gallons per minute. At such places the leakage was grouted off, by injecting about 100 bags of cement, mix ½ bag of cement to about 14 gallons of water, through about twenty 6-foot drill holes. Where these flows were encountered the thickness of the concrete lining was increased by 3 inches.

Drilling was carried on by jack-hammer drills, generally to a depth of 8 feet. The usual number of holes to a round consisted of 11 sump holes, 10 relief holes and 16 trimming holes. The sump holes were generally drilled first, shot, and the muck partially cleared away, before the relief and rim holes were drilled. The maximum weekly progress in shaft sinking was 26 linear feet, being made with two shifts. If the rock has a tendency to spall off, the shafts are concrete lined in about 50-foot stretches as they are sunk, but if the rock is sound it is lined in 50-foot lifts after completion of excavation.

Power for tunnel work. All plant is operated by electricity, storage-battery motors being used to haul muck both in the tunnel and on the surface. To furnish power for the tunnel work, a high-tension transmission-line was built from Saw Kill, near Kingston, where connection is made with the Central Hudson Gas and Electric Company's lines. This line is 48 miles long and was later extended six miles to supply power for the Gilboa dam, thus making 54 miles of specially constructed power-lines for the Schoharie work. The service on the electric power line has been satisfactory, the whole line being out of service for only 27 hours during the last year.

Geological conditions. The rock through which the tunnel is being excavated is of sedimentary origin of the Devonian age, and is shale or sandstone with widely varying degrees of hardness.

The shales, mostly red with small amounts of blue or green color, drill easily, break well to line and usually stand well for a limited time, but they have a marked tendency to disintegrate rapidly when exposed to atmospheric conditions. The red sandstones are of slightly coarser texture, but are often difficult to distinguish from the shales; almost invariably the two are more or less mixed and, when penetrated in the roof of the tunnel, support is usually needed.

The gray and blue sandstones, which are the hardest and coarsest grained of all stones in this vicinity, are consequently more difficult to drill and shoot, but have the advantage of requiring very little scaling and, when not too thinly bedded, generally stand well without support. The phenomenon of "popping rock" frequently occurred in the gray sandstones with a consequent need of roof support.

The inflow of water at the several locations has never been so great as to impede the work or to require other than ordinary methods for its control. The maximum and minimum average inflow per minute for the last year occurred in Shafts 1 and 7 and amounted to 74 gallons per minute and 7 gallons per minute, respectively.

Tunnel driving. The type of tunnel driven from the several headings has been subject to frequent changes from Type A to Type C, and vice versa, because of changes in the character of the materials encountered. The top-heading method and hand mucking were used for practically the entire period at Shafts 1, 3, 4 and 5 and Shaft 7 South, and the full-faced method with machine mucking at Shafts 6 and 7 North. Shifts were in general so organized as to permit of two shots and one shot per day in the top heading tunnels and alternate advances of two shots and one shot per day in the full-faced tunnels. Trimming, above a plane one foot above the finished concrete invert elevation, was carried along closely behind the main excavation. Water Leyner drills, mounted on vertical columns, were used in headings and jack hammers in the bench.

The average progress of tunnel excavation, including the time worked in each heading, has been 61 linear feet per heading per week. No tunnel excavation has been done from the Intake shaft, the Outlet portal or from Shaft 2 in consequence of which the driving

Tunnel Excavation Progress

May 1, 1921 to May 1, 1922

Heading		Excavated during year, linear feet	Supported lengths for year, linear feet	Average weekly progress of excavation, linear feet
Shaft 1	North	5,532	716	106.4
	South	6,216	0	119.5
Shaft 3	North	5,430	1,050	104.4
	South	4,513	2,108	86.8
Shaft 4	North	4,850	949	93.3
	South	4,710	1,942	98.1
Shaft 5	North	4,169	3,919	86.8
	South	4,476	2,075	93.2
Shaft 6	North	3,905	3,907	75.1
	South	4,174	4,177	80.7
Shaft 7	North	3,207	3,213	61.7
	South	4,870	1,236	110.7
Total, 12 headings		56,052	25,292	1,113.6
Average per heading		4,671	2,108	92.8

from the adjacent headings has been pressed with special vigor. The distance between Shaft 1 and Shaft 3 is the maximum distance between shafts worked, being 23,819 feet, or 4.5 miles. The heading from Shaft 1 North is now in 10,402 feet; Shaft 1 South, 9910 feet and Shaft 7 South, 7735 feet. During the last year, excavation has been maintained at as high a rate as it is practicable to attain and the progress in the various headings is given in the above table.

Transportation of tunnel muck to the shafts was accomplished by means of electric storage-battery locomotives, pulling six or seven end-dump cars, each averaging about one cubic yard of solid rock. The cars were carried singly on the cages to the top of the shaft, where they were pushed by hand to the tipple, and dumped into side-dump cars of four cubic yards capacity, which were in turn taken to the dump by means of storage-battery locomotives, the latter of which operated at an average speed of five or six miles per hour.

Tunnel support. A large percentage, much larger than estimated, has required roof support, about 45 per cent of the tunnel thus far being supported by either permanent or temporary timbering, which are practically of the same design. The temporary types, being placed within concrete limits, will be removed before the lining is placed and are therefore not dry-packed with rock. In case the over-breakage above the temporary support is 18 inches or more, cord-wood packing is required. In both types, the arch ribs, usually spaced 7.5 feet center to center, are formed of three 10-inch x 10-inch timbers supported on each side by three $1\frac{1}{4}$-inch steel pins 30-inches long, set 24 inches in holes drilled in the rock. Previous to 1921 the lagging was 4 x 4 inches, spaced 2 to 4 inches apart, dependent on over breakage, but as it was found difficult to place dry packing over this, because thin slabs of rock fell between the lagging, 3-inch x 10-inch planks spaced slightly apart to allow free flow of grout, were substituted.

The pin-supported timber has not the advantage of the rigid support of a wall plate, and to keep the ribs in place it was found necessary to use lacing consisting of 2-inch x 10-inch planks 7.5 feet long, spiked to the under side of the arch rib. Where the roof was of such character that the timber could be kept 40 to 50 feet back of the excavation, seven such pieces of lacing were judged sufficient but when the support had to be kept very close to the heading, the con-

tractor in order to avoid shooting down the arch ribs, elected to use a much larger number, often twelve to fourteen to the bent. The inclined arch legs, which vary in length at each rib, were cut from a templet at the top of the shaft. When the ground permitted, the timber was carried about 100 to 150 feet back of the heading so as not to interfere with drilling and mucking operations.

Generally it has been found necessary to place permanent timber whenever the roof was in soft red shale, in thinly bedded sandstone, or when "popping rock" occurred. In the red shale, the roof would appear to be sound and self-supporting at the time of excavation, but within a few days or weeks disintegration would be seen and a bad fall of the roof would occur, this action repeating itself over and over. When the roof is supported the action is arrested. Including all items of extra excavation, timber, steel, concrete, etc., permanent timbering adds about $25 per linear foot of timbered tunnel.

To demonstrate an element of uncertainty in estimating the cost of works of magnitude there are given here the lengths of timbered tunnel, including both types for the Northern and Southern portions to April 12, 1922:

	EXCAVATED	SUPPORTED
	feet	*feet*
North portion	30,897	3,701
South portion	46,926	27,988
Total to date	77,823	31,689

Concrete tunnel lining. Concrete for tunnel lining will be in the proportion of 1 cement to 7 sand and stone aggregate, which makes about 1.5 barrels of cement to the cubic yard of concrete. During excavation some selected stone from tunnel muck was crushed for concrete and the remainder required will be obtained from quarries being opened for the purpose. Concrete will be mixed at the top of each shaft and discharged into a hopper which is set on top of a vertical 8-inch iron pipe carried down the shaft. At the shaft bottom this pipe will discharge into concrete cars, which will be hauled to the forms by the storage battery motors. The side-wall footings and the tunnel invert will be concreted first, operations which are carried out very rapidly. The tunnel track is re-laid on the invert and the invert also gives a uniform base for the trailing side-wall and arch

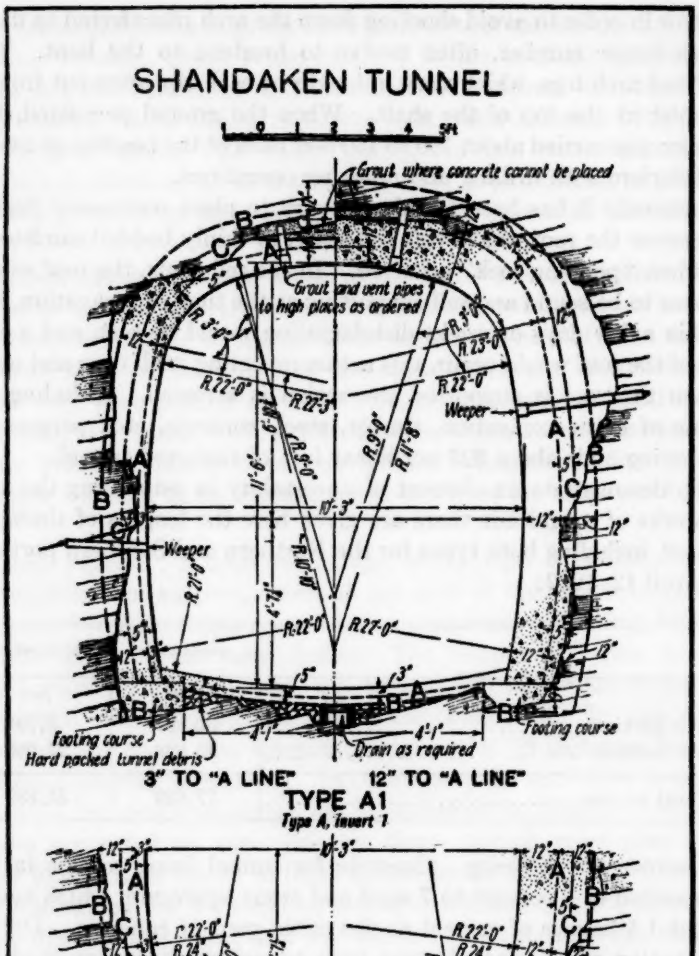

SHANDAKEN TUNNEL
Grout where concrete cannot be placed
Grout and vent pipes to high places as ordered
Weeper
Footing course
Hard packed tunnel debris
Drain as required
3" TO "A LINE"
12" TO "A LINE"
TYPE A1
Type A, Invert 1
Surface of fine material, or other grout stop
Drain as required
Not more than 12"
Selected porous material where required for local drainage
3" TO "A LINE"
12" TO "A LINE"
INVERT 2

FIG. 10

forms which are usually made up in multiples of 15-foot lengths. In the early stages of the Catskill work, the daily lengths of side-wall and arch concreted were at first 30 to 45 foot units, but these were later increased to 60 to 120 foot units. The lengths have not yet been determined for this tunnel. The side-walls are cast to about the springing line at the same time as the arch is being cast in the section immediately to the rear. In the off-shift the forms still further to the rear are brought through and set up for the ensuing day's work. There is no reinforcement or waterproofing in the concrete. The space between the concrete lining and the rock roof of the tunnel will be grouted with thick sand and cement grout and water-bearing seams will be grouted under high pressure, but the lighter lining is not designed to take general high-pressure grouting. Weep pipes are placed through the side-wall concrete at intervals to prevent the building up of hydrostatic pressure on the back of the lining.

The average effective thickness of the lining is in general 8-inches ("C" line); no rock may project nearer than 3-inches to the face ("A" line); the contractor is paid for both excavation and concrete to a line ("B" line) in general 12 inches outside the net excavation limits, i.e., from the "A" line or the back of the timber, this 12-inches being the result of experience in the matter of rock breakage on previous tunnels. The contractor is paid nothing for excess excavation and a pre-fixed price of $3.00 per cubic yard for "excess concrete." There are also many other items of payment covering all contemplated contingencies due to changes in geological conditions.

Required progress. The contract requires the completion of underground work so as to carry water within 78 calendar months and the completion of the entire work in 7 years. The following progress is specified in the contract:

Estimated necessary average rates of progress for main operations

operation	rate per calendar month
Excavation and lining of shafts	60 linear feet
Excavation of tunnel...............	275 linear feet in each heading
Trimming invert and setting side-wall footings.....................	750 linear feet in each heading
Lining side-wall and arch...........	700 linear feet in each heading
Lining invert.......................	2,000 linear feet in each heading

Statistics of Ashokan, Kensico and Schoharie Reservoirs

	ASHOKAN	KENSICO	SCHOHARIE
Capacity, total	130,000,000,000 gal.	38,000,000,000 gal.	22,000,000,000 gal.
Capacity, available	128,000,000,000 gal.	29,000,000,000 gal.	20,000,000,000 gal.
Water surface	8,180 acres = 12.8 sq. mi.	2,218 acres = 3.5 sq. mi.	1,145 acres = 1.8 sq. mi.
Land acquired	15,222 acres = 23.8 sq. mi.	4,600 acres = 7.0 sq. mi.	2,372 acres = 3.7 sq. mi.
Elevation of top of dam, above tide	610 ft.	370 ft.	1,130 ft.
Length of reservoir	12 mi.	4 mi.	5.8 mi.
Length of shore line	40 mi.	30 mi.	16.5 mi.
Length of dams and dikes	5½ mi.	3,300 ft.	2,000 ft.
Main dam:			
total length	4,650 ft.	1,825 ft.	2,000 ft.
length of masonry portion	1,000 ft.	1,825 ft.	1,300 ft. (Earth, 700 ft.)
height (maximum)	252 ft.	307 ft.	160 ft.
thickness at base (maximum)	190 ft.	233 ft.	158 ft.
thickness at top (minimum)	23 ft.	28 ft.	15 ft.
Width of reservoir:			
maximum	3 mi.	3 mi.	0.7 mi.
average	1 mi.	1 mi.	0.4 mi.
Depth of reservoir:			
maximum	190 ft.	155 ft.	150 ft.
average	50 ft.	52 ft.	57 ft.
Villages submerged	7	1	1
Permanent population of submerged area at beginning of work	2,000	500	350
Cemeteries removed	32	none	7
Bodies reinterred	2,800	none	1,300
Railroad relocated	11 mi.	none	none
Highways discontinued	64 mi.	14.8 mi.	13.6 mi.
Highways built	40 mi.	15.1 mi.	12.4 mi.
Highway bridges built	10	4	2
Earth and rock excavation	2,500,000 cu. yds.	1,400,000 cu. yds.	488,500 cu. yds.
Embankment	7,300,000 cu. yds.	2,010,000 cu. yds.	617,000 cu. yds.
Masonry	900,000 cu. yds.	965,000 cu. yds.	436,000 cu. yds.
Cement	1,200,000 barrels	897,000 barrels	480,000 barrels
Maximum number of men employed	3,000	1,500	600

TASTE AND ODOR IN THE NEW YORK CITY'S SUPPLIES[1]

By Frank E. Hale[2]

In New York City's supplies, despite the diversity of its sources, the only organisms which have given offense from taste or odors have been Asterionella, Tabellaria, Anabaena, Aphanizomenon (with admixtures of Coelosphaerium, Microcystis and Clathrocystis), Uroglena, Synura, Dinobryon and Peridinium.

Asterionella produces a slightly aromatic odor when present in 500 to 1000 standard units per cubic centimeter. At 1000 units, and rarely less, the odor is distinctly similar to that of the geranium. The intensity of odor increases with increasing numbers until a fishy odor is produced by several thousand. The fishy odor may also be produced when smaller quantities die or are destroyed.

Tabellaria, and similarly Asterionella, may produce an earthy odor when present in very small amounts (produced also by large amounts of Synedra). The odor passes through the aromatic, geranium and fishy stages with about the same relative quantities of organisms as Asterionella. At times the odor of Tabellaria has suggested illuminating gas, no other organism being present.

Anabaena and Aphanizomenon, when present in 500 to 1000 units, produce a faintly grassy odor, like freshly-cut grass. With larger numbers the odor increases until it becomes pungent like nasturtium, or even onions. Upon decay the odor is of vile, pig-pen character.

Uroglena produces an oily fishy taste and odor, first noticeable in probably 500 to 1000 units. In larger quantities it is very disagreeable, the flavor being that of cod-liver oil.

Synura may cause trouble apparently in any amount judging from our recent experience, at least as little as 50 units. This organism is by far the most persistent and disagreeable of them all. The taste is variously described as cucumber, muskmellon, fishy, etc. It leaves a bitter after-taste when the undestroyed organisms are in the

[1] Presented before the Philadelphia Convention, May 19, 1922.

[2] Director of Laboratories, Mt. Prospect Laboratory, Brooklyn, N. Y.

drinking supply and with small numbers there is very slight first-taste. Water containing the dead organisms has an immediate first-taste and practically no after-taste.

In the spring of 1919 extensive complaints of fishy taste in the Catskill supply were occasioned in New York City by only 700 units of Tabellaria. This was the result of chlorination with liquid chlorine (0.15 p.p.m.) at Kensico reservoir, the chlorine liberating the distasteful oil. The odor was not noticeable in the water above the chlorination plant, but appeared first just below the plant. Last December, 50 to 100 units of Synura occasioned complaints of fishy and cucumber taste after passing the Kensico chlorination plant with 0.3 p.p.m. chlorine. The taste was hardly noticeable with 0.10 p.p.m.

The control of odors from microscopic organisms means either the control of the organisms themselves or the destruction of the odors.

The first method of control is to shut off the troublesome reservoir and to allow it to stand, if possible. In three weeks to three months the trouble will usually disappear. In the Catskill water, however, for some reason growths have a habit of lasting for months, particularly in the fall and winter. For example, Asterionella appeared in Ashokan reservoir in quantity in November, 1919, and lasted until March, 1920. Tabellaria prevailed in Kensico reservoir from February to June, 1919, and Aphanizomenon from June to September, 1919, reaching a maximum of 5000 units. Dinobryon has been present in Silver Lake reservoir, Staten Island, from last October to the present date, although this reservoir has practically no circulation. This method cannot usually be employed with certain of the reservoirs which are not equipped with a bypass.

The second method is to shift draft from one portion of a reservoir to another, if possible, as, for instance, from the east basin to the west basin at Ashokan reservoir. This has been continually practiced since the Catskill supply was introduced. Draft at Croton Lake may be at the new dam or three miles back at the site of the old dam.

The third method is to shift draft from one depth to another and this scheme is frequently employed. In 1912 the policy of deep draft at Croton Lake was started in order to obtain water cooler, clearer and freer from microscopic organisms. Since then draft has been at about 75-foot depth practically continuously. The effect of this policy is shown by the fact that in 1912 the Croton water

delivered to the City was 5 to 10 degrees cooler during the summer and trouble from heavy growths of microscopic organisms was avoided. During the two previous years, 1910–1911, many complaints were caused by Aphanizomenon. The following table illustrates the beneficial effect:

Reduction microscopic organisms by deep draft. Croton-supply, third quarter—July, August and September

YEAR	TEMPERATURE	MICROSCOPIC ORGANISMS	REDUCTION
			per cent
1911	72°F.	2,836	
1912	67°	1,072	65
1913	65°	677	75

Certain forms, particularly the Cyanophyceae, tend to float in the upper water. As temperature and light, however, have a decided bearing upon the subject the diatoms may at times predominate in the upper water. The occurrence of growths of over 1000 units in the Croton watershed reservoirs in 1921 as referred to surface and bottom samples was as follows:

Prevalence of surface and bottom growths, Croton watershed, 1921; number of occurrences, 1000 units +

	SURFACE	BOTTOM
Diatoms:		
First six months	14	8
Second six months	5	4
	19	12
Cyanophyceae:		
First six months	3	1
Second six months	42	22
	45	23
Total:		
First six months	18*	9
Second six months	47	26
	65	35

* One occurrence of Dinobryon, a protozoon.

With respect to seasonal prevalence it is probable that temperature is the predominant factor, particularly as to when the organisms

start to multiply. Once started they may persist at other temperatures. Aphanizomenon frequently lasts through the winter. Diatoms usually appear in the spring and fall, Cyanophyceae in the summer and fall, and the most troublesome protozoa, Synura and Uroglena, prefer cold temperatures and even grow under the ice. Growths of Dinobryon, Uroglena and Synura which have occurred in warm weather have several times disappeared quickly within a week or two. In a study of last year's growths on the Croton watershed diatoms prevailed the first six months and Cyanophyceae the second six months. The occurrence of growths of over 1000 units with reference to temperature was as follows:

Relation of temperature to microscopic organisms; occurrence of 1000 units+, Croton Watershed, 1921

	30–40°F.	40–50°F.	50–60°F.	60–70°F.	70–80°F.
Diatoms:					
Synedra	3	0	5	2	1
Melosira,	1	5	4	1	1
Fragillaria	1	0	0	0	0
Asterionella	1	8	7	1	0
Tabellaria	0	2	0	0	0
Totals	6	15	16	4	2
Cyanophyceae:					
Aphanizomenon	5*	10	4	7	4
Anabaena	0	5*	7*	9	12
Coelosphaerium	0	0	0	0	1
Mixture	2*	2*	4	5	13
Totals	7	17	15	21	30

* Persistence, not start of growth.

It is noticeable that the diatoms favor 40–60°F. (31 times out of 43). With the possible exception of Aphanizomenon, the Cyanophyceae prefer 60–80°F. Aphanizomenon usually started to increase at 65–75°F., though occasionally at 40–50°F., but Anabaena and Coelosphaerium practically always at over 75°F.

Both the Ashokan and the Kensico aerators have been employed to help remove the taste and odor-producing oils from microscopic organisms. The odor to leeward of the spray, when the wind is blowing, is obvious when growths are prevalent. Certain delicate organisms are partially disintegrated, as Uroglena, Synura, Dinobryon, Anabaena, and Asterionella. For example, in the middle of

August, 1919, the Ashokan aerator was used to break up Dinobryon, 500 to 1500 units. In March and April, 1918, and from October to December, 1919, the Ashokan aerator helped to hold Synura in check so that it did not reach Kensico reservoir in sufficient numbers to develop. In 1917, the two aerators controlled Uroglena. It is not the air but the splashing and jolting that produces the effect and only partial assistance may be expected from this source, particularly as there is no assurance that the individual units are killed.

The method of widest application is that of Moore & Kellerman. The usual method of applying copper sulphate has been to drag burlap bags, containing about fifty pounds each, through the water by means of row-boats, taking a zig-zag course so as to triangulate the surface of the water. Wind, waves, diffusion and gravity admix the streaks of treated water with the remainder. It is remarkable how successful treatments made in this crude manner have been. On the extensive reservoirs of the watersheds it is necessary to use launches and the chemical is shoveled at frequent intervals into bags suspended from either side. In the last few years that portion of Kensico reservoir lying between the influent and effluent gatehouses has been successfully treated in two days time with approximately 6000 pounds of copper sulphate. This treatment has been made on several occasions at different seasons, including the winter. On many other occasions 3000 pounds have been applied to Croton Lake and once on Kensico reservoir. In these launch treatments of large reservoirs parallel courses about 100 feet apart are usually taken.

Beginning in January, 1920, a new departure was made. Copper sulphate was applied continuously for weeks at a time, aggregating three months of the year, to the water in the aqueduct at Pleasantville, about an hour's flow above Kensico reservoir. This plant was designed to feed alum in case of high turbidity but has never been necessary for that purpose. The chemical feeds through a hopper to a moving shutter actuated by a motor and adjustable in stroke. The chemical drops into a wire drum which revolves in a portion of the aqueduct narrowed to seven feet. Vanes on the drum cause it to be revolved by the current of the water. The chemical feeds through a 6-inch pipe of iron into each end of the drum at the centre. Such apparatus should be made of copper for use with copper sulphate. Owing to corrosion of the iron pipe leading to the ends of the drum where the water and chemical first come together, a floating wooden crib bored full of holes and fed by a wooden chute has since

been substituted. The electric feed originally designed for over 17 tons a day has fed 400 pounds a day within a pound error. No attention at night has been required. This continuous dry feed of copper sulphate to the water has been eminently successful. The dosage of chemical is definitely known and the application and admixture with the water thoroughly under control. At winter temperature 0.2 p.p.m. killed Asterionella and at spring temperature 0.12 p.p.m. Recently 0.12 p.p.m. killed Synura at Ashokan screen chamber, although 0.25 p.p.m. was more thorough, prompt and complete. In 1920, 34 tons of copper sulphate were used altogether in control of microscopic organisms, of which 25 tons were applied automatically to the Catskill aqueduct. About 8 tons are used yearly on the Croton watershed.

The effect of treatment of microscopic organisms by copper sulphate is shown by an immediate production of distinctive odors, by reduction of the number of organisms in the water through sedimentation, by the appearance of the organisms under the microscope,—the coloring matter being knocked to pieces, so to speak. Sometimes there is an increase in the water bacteria which feed upon the decayed organisms. The Cyanophyceae may produce scum after treatment, of varied colors, pale, blue, yellow, red or brown.

The following table gives the dosages which have been found successful under varying conditions in our supplies:

Copper sulphate required for treatment of different species

ORGANISMS	PARTS PER MILLION	POUNDS PER MILLION GALLONS
Diatomaceae:		
Asterionella	0.12*–0.20*	1.0–1.7
Synedra	0.50	4.2
Tabellaria	0.12*–0.50	1.0–4.2
Cyanophyceae:		
Anabaena	0.12	1.0
Aphanizomenon	0.12–0.50	1.0–4.2
Clathrocystis	0.12–0.25	1.0–2.1
Coelosphaerium	0.20	1.7
Protozoa:		
Dinobryon	0.25	2.1
Peridinium	0.50	4.2
Synura	0.12*–0.25*	1.0–2.1
Uroglena	0.05–0.10	0.4–0.8

* Starred dosage has also been successful in automatic treatment by dry feed in the aqueduct.

A résumé of the recent experience with Synura would seem of interest. Our experience with this organism goes back many years but the amount causing trouble was the smallest in that experience. The Brooklyn supply suffered from it many years ago and the Croton supply in 1900. On those occasions there were about 300 to 500 units in the service taps. The present year seems to have been a Synura year. It has appeared in a Newark reservoir and in the Boston supply. It has appeared in almost every supply of New York City this winter, the Catskill, Croton, Bronx, Long Island and Queens watersheds as follows:

Catskill	Ashokan and Kensico reservoirs
Croton	Sodom reservoir, West Branch reservoir, Amawalk reservoir, Middle Branch reservoir and Croton Lake
Bronx	Wampus pond, Byram Lake
Long Island	Massapequa, East Meadow, Pine's, Valley Stream and Watt's Ponds
Queens	Oakland Lake.

Synura has been present in Ashokan reservoir in all four years, 1918, 1919, 1920 and 1921, but up to the last year the measures taken had been effective. It began to appear in August, 1921, and was present in about 100 units by October. Watch was kept for it in the water entering Kensico reservoir, but, as it escaped discovery, it was assumed, as in the experience of the previous years, that it was destroyed by the Ashokan aerator and by passage through the miles of tunnel with its many invert syphons and particularly by the pressure of 700 pounds per square inch to which it was subjected in passing under the Hudson River. However, a sufficient quantity must have survived to seed Kensico reservoir and about 100 units became prevalent there by the middle of December. At that time complaints of fishy taste began to come in from upper Manhattan. The water had practically no odor but the taste was traced back to the chlorination plants. It was noticeable after, but not before, chlorination. The dosage of chlorine was 0.3 p.p.m. and the chlorine was killing the organism and setting free the oil. It happened that Hillview reservoir at the time was out of service because of contamination by seagulls. The first measure taken was to put Hillview into service, expecting, in accordance again with the previous experience with other organisms, that the two days storage would remove the taste. It did not. In fact, the taste passed through double filtration of sand and charcoal in the Municipal building in lower

Manhattan. As Kensico reservoir froze over in a sudden cold snap that occurred about that time it was impossible to treat the reservoir direct. Automatic treatment of the incoming water with copper sulphate was started at Pleasantville. Owing to the failure of Hillview reservoir to remove the taste, the next step was to bypass Kensico reservoir, since only about 50 units of Synura were coming from Ashokan reservoir. But the treatment with copper sulphate at Pleasantville followed by chlorination at Kensico brought out all of the taste of the organism, so that a second wave of complaints swept over the City. The next attempt was to avoid destruction of the organism by stopping treatment with copper sulphate, shutting down the Kensico aerator and reducing the chlorine to 0.1 p.p.m. This produced a nearly tasteless water at Hillview reservoir, but accumulation of the organism in local sections caused further complaints. The next step was to shift treatment with copper sulphate to Ashokan screen chamber. This was first tried experimentally for sixteen hours so that if unsuccessful the treated water could be caught and held at Hillview reservoir. The object was, first, to learn whether the copper sulphate would kill the organisms in the aqueduct in the absence of light and, second, whether the passage through the long 92 miles of aqueduct would remove the taste. Samples, of course, had to be accurately timed for flow in the aqueduct. After several experiments it was learned that 0.12 p.p.m. copper sulphate killed the organism almost completely, at least 60 per cent, but the water still tasted of cucumber at Hillview reservoir, that 0.18 gave similar results, but 0.25 p.p.m. completely destroyed the Synura and so quickly that the water was tasteless when it reached Hillview reservoir. Dosage with chlorine was 0.3 p.p.m. at this time. Consequently treatment at Ashokan was started continuously with 0.25 p.p.m. copper sulphate and the Kensico aerator put into operation again. Meantime it was learned that after killing the organism with copper sulphate, the chlorine did not increase the taste but helped to decrease it, hence dosage was maintained at 0.3 p.p.m. again. Since then the water reaching the City has been without the cucumber flavor.

In order to learn other means of handling such a situation, which has a decided bearing upon the other large supply, the Croton, the next study was to increase the chlorine. As the apparatus was feeding its maximum at Kensico, the flow of water was cut down, running the excess into Kensico reservoir. It was found that 0.6 to

0.75 p.p.m. chlorine destroyed the taste and after 12 to 24 hours the chlorine could not be tasted. (The water at this time was treated at Ashokan Screen Chamber with 0.12 p.p.m. of copper sulphate.) A similar experiment on a smaller scale, 12 mgd., was tried on the Bronx pipe line, blowing off the water to the Harlem River, and it was found that 0.6 to 0.75 p.p.m. chlorine both killed the organism and removed the taste and yet the chlorine could not be tasted after flowing the 15 miles through the pipe line, in fifteen hours. Following this experiment, the pipe line was in service a week with chlorine dosage at Kensico dam of 0.6 to 0.75 p.p.m. without causing complaint in the City. As a result the chlorine equipment has been increased at Kensico and in the latter part of February treatment with copper sulphate was stopped and reliance placed on the chlorine using the regular 0.1 p.p.m. excess residual. Draft however has been from the west basin Ashokan reservoir in which no recognizable Synura has occurred for some time though the taste persisted.

On March 30 and 31, Kensico reservoir was treated with 6000 pounds of copper sulphate and turned into service on April 1 with no resulting taste. The Synura is still present in the east basin Ashokan reservoir. In the solving of the difficult situation created by the Synura, hundreds of samples were taken and tasted and it became necessary for Deputy Chief Engineer, William W. Brush to assume personal direction of the extensive large scale experiments carried on.

THE MELCROFT COAL COMPANY CASE[1]

By F. Herbert Snow[2]

This case is a proceeding brought in the Court of Common Pleas of Fayette County, Pa., Sitting in Equity, by the Mountain Water Supply Company, Dunbar Water Supply Company and the Pennsylvania Railroad Company, Complainants against The Melcroft Coal Company, Defendant.

The Mountain Water Supply Company is a Pennsylvania Corporation, chartered March 13, 1902, with an authorized capital stock of $5,000,000 and issued and outstanding $1,467,900, all of which is owned by the Pennsylvania Railroad Company.

The Mountain Water Supply Company was incorporated for the purpose of storing, transporting and furnishing water, with the right to take rivulets and land, erecting reservoirs for holding water for manufacturing and other purposes, and for the creation, establishment, transmission and use of water power therefrom and of acquiring all the rights, powers and privileges conferred upon corporations for said purposes under laws of Pennsylvania.

The Pennsylvania Railroad Company was created by virtue of an Act of the General Assembly of Pennsylvania, approved April 13, 1846, and is possessed of the powers conferred by said Act and various supplements and amendments thereto, among which is the Act approved April 22, 1905, entitled "An act to authorize railroad Companies of this Commonwealth, in order to secure an adequate supply of water for their corporate purposes, to acquire, hold, dispose of and guarantee the stock and securities of water companies."

It is alleged in the complaint that on March 22, 1902, The Mountain Water Supply Company appropriated for its corporate purposes the waters of Indian Creek, in Springfield Township, County of Fayette, at, above and flowing into said stream at the dams, intake and water works referred to in the appropriation resolution of its

[1] Presented before Central States Section meeting, November 2, 1922.

[2] Chief Engineer, Pennsylvania Public Service Commission, Harrisburg, Pa.

Board of Directors, together with the necessary lands, for the purpose of constructing, maintaining and operating thereon its works, dams and spill ways. The Melcroft Coal Company, Defendant, denies that The Mountain Water Supply Company has appropriated for any purpose any of the water of Indian Creek as the same are wont to flow upon and across its lands and denies that said water company has appropriated any of the coal companies' right in regard to said Indian Creek or has appropriated for any purpose the coal company's right of drainage of its lands or of its mines and lawful establishments erected in and upon said lands, and the coal company denies that The Mountain Water Supply Company lawfully appropriated any of the company's property or property rights and charges that the water company has no power of eminent domain, and is without authority or legal right to appropriate any of the coal company's land, water or property rights.

On June 22, 1904, The Mountain Water Supply Company appropriated the lands necessary for construction and maintenance of reservoir dams, spill ways, etc., on which its masonry dam and storage reservoir were actually constructed and are now located and maintained.

On April 7, 1905, The Mountain Water Supply Company also appropriated the right of way required for the laying of pipes to conduct water from said Indian Creek into the townships of Springfield, Bullskin and Connellsville, Fayette County.

The Mountain Water Supply Company agreed with the owners and all persons, corporations and parties affected or damaged by its appropriation of the waters of Indian Creek, as well as the lands, right of way, etc., for the compensation proper for the damages done to, or likely to be done to, or sustained by said owners or parties by reason of the said appropriation, as well as any damages done to, or likely to be done to or sustained by said owners or parties otherwise, howsoever, they arise; in pursuance of which agreements and in consideration of the settlement and payment of the damages so agreed upon the said owners and parties released and discharged The Mountain Water Supply Company of and from all claims and demands for damage done to, or likely to be done to or sustained by them. Said owners also conveyed, released and transferred to the water company all of the rights, title interest, etc., belonging to or vested in them, in and to the Indian Creek and its tributaries and the waters thereof, or the right to use the same as the stream then flowed or might thereafter flow.

The Melcroft Coal Company denies that the Mountain Water Company agreed with it or with any of its predecessors in title as to any compensation, or settled or paid any damages or released or discharged said water company from any claims and damages as alleged in the Bill of Complaint.

To enable it to utilize and supply water, the Mountain Water Supply Company has constructed and maintains a masonry dam on Indian Creek located about 4 miles above its mouth, which dam was completed in December, 1905, the capacity thereof being 251,000,000 gallons, with a gate-house with suitable blow-off and controlling valves and a screen pot for removing foreign material from the water; and has also constructed a line of 36 inch diameter cast iron pipe, 13.7 miles long, by means of which water is conveyed from the dam to the points where it is delivered to the consumers. The Mountain Water Supply Company has also constructed and maintains at South Connellsville, 10.1 miles below the masonry dam, a reinforced concrete reservoir having a capacity of 6,500,000 gallons as a local storage reservoir and an equalizing basin, together with a gate-house along the pipe line with necessary valves, meters and other equipment, for the successful operation of the system, and has also completed and placed in service a pumping station at the mouth of Indian Creek whereby the pressure in said pipe line is increased and in consequence a greater quantity of water can be delivered through the line, and in addition the Mountain Water Supply Company is enabled to pump water from the stream direct into the line. All of the above facilities were constructed by the Mountain Water Supply Company at a cost of more than $1,700,000.

Indian Creek drains a section in the south eastern part of Westmoreland County and the north eastern part of Fayette County, lying between Chestnut Ridge on the north west and Laurel Ridge on the south east. The source of Indian Creek is in Donegal Township, Westmoreland County, from which source it flows in a general southwesterly direction through Fayette County a distance of 23 miles, emptying into the Youghiogheny River at Indian Creek Station on the Baltimore and Ohio Railroad about 7 miles above Connellsville Station. The lower portions of the Valley and the mountain sides comprising more than one-half of the total water shed or drainage area, are covered with timber and the balance is mostly clear land under cultivation.

The entire flow of the stream at the mouth of Indian Creek and at the dam, where the waters thereof are introduced into the pipe line, is and also has been pure, uncontaminated and of good quality, well adapted for domestic consumption and use and for supplying water for locomotive engines so it is alleged, until the recent wrongful action of the Defendant Coal Company and others. But to this allegation The Melcroft Coal Company except. The Coal Company denies that the flow of Indian Creek has always been pure, uncontaminated and of good quality and avers that for many years past, the water of Indian Creek has been to a considerable extent impregnated with water which has drained from coal mines and other establishments located on the water shed of Indian Creek. The Coal Company further avers that the waters of Indian Creek are now reasonably well adapted for domestic consumption and use and for supplying water for locomotive engines.

The Pennsylvania Railroad Company, now is, and, for many years past, has been, operating a railroad between the City of Pittsburgh and the city of Philadelphia together with numerous branches thereof, inter alia: The South West Branch extending from Greensburg to the Borough of Fairchance in the County of Fayette; the Monongahela Division extending from Pittsburgh along the Western Branch of the Monongahela River through the boroughs of Donora, Monongahela City and Charleroi through West Brownsville, also the Red Stone Branch extending from near Uniontown to Brownsville.

To enable it to conduct its operations, the Pennsylvania Railroad Company requires for its engine supply and other purposes a very large amount of water of the quality and purity which will permit its use in the boilers of locomotives without injury thereto. To meet in part its water requirements, The Pennsylvania Railroad Company made to the stock holders of the Mountain Water Supply Company loans or advances necessary to enable the Mountain Water Supply Company to acquire the waters of Indian Creek and to make the developments hereinabove referred to, and subsequently acquired under and by virtue of the Act of April 22, 1905, all the stock of the said Mountain Water Supply Company in order that it might secure for all the time a supply of water for its corporate purposes through and by means of the facilities of the Mountain Water Supply Company.

The Melcroft Coal Company denies that the Mountain Water Supply Company has acquired the waters of Indian Creek or any

rights therein, which in any way affects the Coal Company's lands or the Coal Company's right to lawful drainage of its lands. The Coal Company avers that the Dunbar Water Supply Company is not engaged in supplying water to the public in Dunbar Township, Fayette County, and requires no part of the waters mentioned in the Bill of Complaint for such purpose. And the Coal Company charges that the Dunbar Water Supply Company has no part of eminent domain and is without authority or legal right to appropriate any of the Coal Company's lands, water, or property rights.

The Mountain Water Supply Company since the year 1906 until the present time has been furnishing from its supply obtained from Indian Creek to the Pennsylvania Railroad Company water necessary for the Railroad Company's purposes, including water for the boilers of engines, for use at stations, shops and on the trains. During the year 1918 The Pennsylvania Railroad Company received from the Mountain Water Supply Company an average amount of 5,700,000 gallons of water per day, an amount insufficient for its present corporate requirements, so it was alleged.

The Dunbar Water Supply Company, a Pennsylvania corporation chartered December 5, 1904, for the purpose of supplying water to the public in Dunbar Township, Fayette County, appropriated the entire daily flow of Indian Creek and its tributaries, so it is alleged, the water to be taken at the storage dam or reservoir of the Mountain Water Supply Company. This is denied by the Coal Company as against it or any of its predecessors in title.

On April 26, 1906, the Dunbar Water Supply Company appropriated the rights of way necessary for the location, construction and maintenance of pipes, conduits and other structures and equipment to be used in connection with the conveyance, transportation and the supply of water to be obtained from Indian Creek.

It is alleged that the Dunbar Water Supply Company agreed with all persons affected or damaged by its appropriation and taking by eminent domain, of the waters of Indian Creek as well as the lands, right of way, etc., for the compensation for the damages done to or likely to be done to or sustained by the owners by reason of said appropriation or otherwise arising howsoever, and has paid and discharged all damages as aforesaid due. It is further alleged that as part settlement and payment of the damages aforesaid the Mountain Water Supply Company entered into an agreement with Dunbar Water Supply Company, permitting the latter to divert from the

storage dam on Indian Creek such water, not in excess of 2,000,000 gallons per day, as might be required by Dunbar Water Supply Company, the water to be transported through the pipe line of the Mountain Water Supply Company from its storage dam to the pipe line of Dunbar Water Supply Company in Connellsville. Since the year 1908 Dunbar Water Supply Company has received from this source 1,500,000 gallons of water and upwards per day, and has been supplying the same to The Pennsylvania Railroad Company and Monongahela Railway Company, the former receiving about 1,200,000 gallons per day and upwards.

The Melcroft Coal Company denies any such agreement by it or any of its predecessors in title with the Dunbar Water Supply Company for any compensation for any damages done or likely to be done to or sustained by the Coal Company by reason of any of the alleged appropriation mentioned in the Bill of Complaint and denies that the Water Company has paid or discharged any damages to the Coal Company or any of its predecessors in title.

The Mountain Water Supply Company by agreement dated April 27, 1910, with Westmoreland Water Company, agreed to supply and has been supplying Westmoreland Water Company with large quantities of water which has been and is being distributed by Westmoreland Water Company to its domestic consumers, the minimum amount being 1,000,000 gallons daily and the maximum amount 2,000,000 gallons daily. In the year 1934 the minimum amount to be supplied to Westmoreland Water Company will be 2,775,000 gallons and the maximum 5,500,000 gallons daily. The water thus supplied by the Mountain Water Supply Company to Westmoreland Water Company constituted 38 per cent of the total water distributed by Westmoreland Water Company to its domestic consumers during the year 1918. Said Westmoreland Water Company was incorporated for the purpose of supplying water to domestic consumers and serves an important industrial section lying between the Borough of Youngwood on the east and the Borough of Irwin on the west, including the boroughs of Youngwood, Greensburg, Jeannette, Penn, Manor and Irwin, and the territory adjacent to each.

On December 31, 1910, the Pennsylvania Railroad Company purchased and acquired the entire capital stock of the Mountain Water Supply Company and the entire capital stock of Dunbar Water Supply Company for the purpose of enabling it to secure an adequate supply of water for its necessary corporate purposes.

The Pennsylvania Railroad Company, in order to obtain the full benefit of the waters thus secured from Indian Creek through its ownership of the capital stock of the Mountain Water Supply Company and Dunbar Water Supply Company, has constructed and maintains an extensive water facility to conduct the water to the points of consumption and to store the same in small reservoirs so that it may be available when needed in the case of breaks in the pipe lines. This system comprises approximately 130 miles of cast iron pipe lines, ranging in size from 12 to 36 inches in diameter, 10 reservoirs with a capacity of 56,450,000 gallons, 4 steel stand pipes with a capacity of 4,310,000 gallons, together with the necessary valves, gate-houses, meters and other facilities required for the operation of the system.

The piping system of the Mountain Water Supply Company extends from its storage dam in the Indian Creek Valley along said Creek to the Youghiogheny River, thence parallel to the Baltimore and Ohio Railroad and said river to a point north of Connellsville where it connects with the piping system of the Pennsylvania Railroad Company. The piping system of the Pennsylvania Railroad Company extends from the point last named north along its Southwest Branch to the main line of The Pennsylvania Railroad at Radebaugh and by way of the western leg of the "Y" connection. From this point it extends along the main line to East Pittsburgh where it leaves the main line and parallels its Port Perry Branch through the tunnel crossing the Monongahela River on the Thomson Bridge, practically all of said pipe line being on the right of way of the Pennsylvania Railroad Company.

The piping system of Dunbar Water Supply Company extends from Connellsville, where it connects with the mains of the Mountain Water Supply Company across the Youghiogheny River to the piping system of the Pennsylvania Railroad Company on its right of way. From this point the piping system of the Pennsylvania Railroad Company extends along its Southwest Branch to Red Stone Junction, and thence along Coal Lick Branch to south of Uniontown; thence by another line along the Red Stone Branch to West Brownsville Junction and from thence along the Monongahela Division to the Junction at Thomson with the line previously described. From Thomson the pipe line continues along the Monongahela Division into its 30th Street shops in the City of Pittsburgh.

All the dams, structures, pipes and other facilities of the Mountain Water Supply Company and Dunbar Water Supply Company hereinabove described, as well as the entire piping system constructed by the Pennsylvania Railroad Company for the distribution of the waters of Indian Creek at the several points along its system, as above described, were constructed and are now being used for the sole purpose of enabling the Pennsylvania Railroad Company, the Mountain Water Supply Company, Westmoreland Water company and Dunbar Water Supply Company to utilize the waters of Indian Creek for their respective corporate purposes and it is alleged that without this supply of water the operations of the Pennsylvania Railroad Company would be seriously hampered and impaired and its ability to perform its duties as a carrier would be materially affected.

The defendant Melcroft Coal Company is a Pennsylvania corporation organized for the purpose of mining and selling coal, having been incorporated November 4, 1917. The Melcroft Coal Company in 1918 acquired and now owns a large area of coal situated in Saltlick Township, Fayette County, the outcrop of a portion of which is in the drainage basin of Indian Creek, and generally higher in altitude than the thread of said stream. It is alleged that prior to the acquisition of the coal and development thereof The Melcroft Coal Company was advised as to the ownership by the Mountain Water Company and Dunbar Water Supply Company of the waters of Indian Creek and of the dams, pipes and other facilities of the water companies constructed and used by them, and was also advised as to the use to which the Pennsylvania Railroad Company and the other Railroads were devoting the waters of Indian Creek and well knowing that the drainage of the waters from said mines, which are highly impregnated with sulphuric acid, would pollute the waters of Indian Creek and if continued would destroy the usefulness of the same, for the purposes of the water companies and Pennsylvania Railroad Company, as well as for use by domestic consumers, The Melcroft Coal Company proceeded to open a mine at a point within the drainage area of Indian Creek and to drain the mine water into the pure waters of Indian Creek thereby polluting the same. It is further alleged that it is the purpose and intention of The Melcroft Coal Company to extend the mines and as it is extended, larger amounts of mine water will be liberated and unless otherwise disposed of will be drained into Indian Creek thereby increasing the pollution and ultimately rendering the same unfit for the use mentioned.

The Melcroft Coal Company denies that it was advised as to such ownership of Indian Creek waters as alleged. It admits that the drainage of waters from its mine would to some extent pollute the waters of Indian Creek and it admits that certain mine waters are to some extent impregnated with sulphuric acid, but the coal company denies that such drainage destroys, or will destroy, the usefulness of the water of Indian Creek. The coal company avers that the right to drain its mine into the stream which forms the natural drainage of its lands is a property right in which it is protected by the 5th and 14th Amendments of the Constitution of the United States and by Section 10 of Article 1 of the constitution of Pennsylvania and that the coal company cannot be deprived of this property right by any person or corporation acting under the authority of the State of Pennsylvania without due process of law or without just compensation being first made or secured.

As soon as the coal company began to construct facilities for the mining of its coal, and before it had expended any considerable amount of money therefor, The Mountain Water Supply Company notified the coal company in writing not to discharge or permit to be discharged any waters or drainage from any coal holes or mines in the Indian Creek or its tributaries, on the water shed of the Mountain Water Supply Company. It is alleged that notwithstanding this notice and with full knowledge that the operation of its mine would inevitably pollute and destroy the waters of Indian Creek then and now being used by the plaintiffs, The Melcroft Coal Company from year to year, since the opening of the mine, has persisted in discharging ever increasing quantities of mine drainage into Indian Creek and if the acts of the coal company are persisted in, the waters of Indian Creek will shortly be polluted to such an extent as to render them utterly useless to the Pennsylvania Railroad Company and unfit for domestic use, commercial and manufacturing purposes. The coal company denies the water will shortly through any act of its be polluted to such an extent as alleged by plaintiffs.

Certain other persons and corporations acquired coal lands, the outcrop of a portion of each of which being within the drainage basin of Indian Creek and generally higher in altitude than the thread of the stream, and it is alleged that each of said other persons or corporations likewise has wrongfully drained into the water of Indian Creek like polluted mine water from their respective mines, thereby increasing the quantity of polluted mine water being cast into Indian

Creek above the dam of the Mountain Water Supply Company, the Dunbar Water Supply Company and the Pennsylvania Railroad Company, all of which wrongful acts have been done in violation of notice from the Mountain Water Supply Company served on each of said parties. It is further alleged that each of said persons and corporations began and continued in such wrongful action with knowledge and notice of the prior and superior right of the plaintiffs in and to Indian Creek Waters and with the knowledge and notice that said wrongful acts were destructive of the pure waters of Indian Creek, in violation of the rights of the public in and to said pure stream of water. The Melcroft Coal Company denies that the rights of plaintiffs in and to the waters of Indian Creek are prior or superior to the rights of any of the owners of the coal.

It is alleged that should the defendants be permitted to persist in the pollution and destruction of Indian Creek, the investment of the water companies and the Railroad Company will be practically destroyed thereby entailing a loss in equipment, etc., amounting to more than $3,500,000 to the Mountain Water Supply Company and a loss of more than $7,500,000 to the Pennsylvania Railroad Company and in addition the operation of the Railroad Company would be necessarily interfered with and impaired as a common carrier. The Melcroft Coal Company denies that any of its actions mentioned have been involved or destroyed or rendered valueless the investments of the plaintiffs or will entail upon them the losses claimed.

The plaintiffs aver that their supply of water from Indian Creek cannot be duplicated within any economical distance from the place where the Pennsylvania Railroad Company receives its water for its corporate purposes; but that the pollution of the waters of Indian Creek by mine pollution would not only unlawfully deprive the plaintiffs of the natural and reasonable use of their property, but would greatly injure and hamper the public service of the Pennsylvania Railroad Company as a common carrier and deprive the inhabitants of the Commonwealth of the use of this large supply of pure water for domestic, commercial and manufacturing purposes; that the plaintiffs, long prior to the purchasing of the coal lands by The Melcroft Coal Company, had lawfully acquired the waters of Indian Creek, had expended large sums of money as hereinbefore described, and had been for many years actually using the same waters for domestic purposes and for commercial and manufacturing purposes and for railroad purposes; that the Melcroft Coal Company

made its investment in the coal lands with full notice and knowledge of the prior and superior rights of the plaintiffs and of the public in and to the use of Indian Creek waters and that the acts of the defendants in so polluting the waters of Indian Creek, constitute an ever increasing public and private nuisance.

The Melcroft Coal Company denies that the Pennsylvania Railroad Company supply of water received from Indian Creek cannot be duplicated within any economical distance; deny that it has destroyed or intends to destroy the waters of Indian Creek by pollution of any kind and denies the other averments in the preceding paragraph.

And for further answer to the matters set forth in the Bill of Complaints the Melcroft Coal Company says that for many years it has been well and commonly known throughout Fayette County and Westmoreland County that the lands comprising the water shed of Indian Creek have been underlaid with a deposit of coal of great value. For more than fifty years, last past, active mining operations of such coal have been carried on at various places throughout the Indian Creek water shed. The natural drainage of more than 40,000 acres of coal, including the Melcroft Coal is into the waters of Indian Creek and it is impracticable and commercially impossible to drain the mine water therefrom into any other stream. The plaintiffs' company had direct notice and well knew it at the times that they severally made their first investments in the water supply system that the Indian Creek, whose waters they proposed to use, constituted the sole drainage from this great coal basin, and were advised and well knew that the development of this coal in the usual and ordinary manner would naturally result in impregnating the waters of Indian Creek with large quantities of mine water.

The Melcroft Coal Company avers that the drainage of mine water from its coal lands into Indian Creek is the natural result of the ordinary and natural use of its property, and is unavoidable and could not be prevented by any method which would not require an expenditure so great as substantially to deprive it of the use of the property. No other drainage for those mines than by Indian Creek is practical or commercially possible. And finally the coal company avers that, if it is prevented from so draining its mines, the operation thereof will be rendered impossible and its property will be rendered valueless.

The plaintiffs pray that the Honorable Court grant an injunction restraining the defendants from discharging, or causing or permitting to flow or to be discharged, any drainage of mine water from their mine or mines into the water of Indian Creek.

The writer in the capacity of a State Officer, and in the discharge of his duties, has during the last seventeen years had more or less intimate connection with the systems of water works and the source of supply hereinbefore described. However, what is herein presented has been wholly taken from the records in the proceedings as contained in the Bill of Complaint and the answers thereto and is offered for the purpose of affording a basis upon which others will discuss the subject. The case has been tried and the issues are before the Court. The determination of the issues is bound to be far reaching in results.

THE GEOPHONE

By Francis W. Collins[1]

What is going on underground is often a matter of such importance and yet so uncertain that it may be of interest to water works men to hear of some experiences with the geophone, a development of underground war operation to detect enemy mining and sapping.

The instrument exteriorly consists of two discs, each about 1 inch thick and 4 inches across, from each of which leads a tube ending in an earpiece. The whole affair is not unlike a stethescope.

In use the discs are placed on the road surface and an earpiece in each ear. If a leak is suspected in a given locality, by placing the two discs as far apart as the lengths of tubes permit, it will be found that the noise in one ear will be louder than in the other. The less loud disc will then be shifted backward and forward until the sounds from both are equal. The assumption follows that the sound is in the plane perpendicular to the straight line joining the two discs. Mark this observation spot, then proceed along the direction of this plane forward or backward whichever way, on trial, intensifies the noise.

The time necessary to locate an ordinary leak when within 50 or 75 feet of it is usually only a few minutes and not over 15 or 20.

There are some points of interest worth following by one using the geophone for the first time:

(a) The operation must be carried on at a time of no traffic or other street noises. It was found that a street sweeping machine of the revolving broom type two or three blocks away on a brick pavement made so much noise that it was distinctly heard in the geophone. The early morning is practically the only time, except in outlying districts, the instrument can be used.

(b) The operator must learn what to listen for. He may pick up all kinds of noises.

(c) The noise from a leak, apparent through the geophone, will depend on against what the leaky water impinges. If the stream is against a ledge of rock, a roar like a cataract may result; the volume of sound does not necessarily

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[1] Consulting Engineer, New York, N. Y. Consulting Engineer, Roanoke Water Works Company.

indicate the size of the leak. No observations have been made as to the effect produced by different characters of apertures through which the leak might be taking place.

Although not tested under all conditions so as to determine what the geophone will not do, enough has been learned through its use to prove its value for what it will do. We are now interested in learning the smallest leaks it will disclose and under what conditions.

Three examples will show what it will do:

(1) A ½-inch service 2½ feet deep, leaking a stream smaller than a lead pencil, under 8 inches of brick and concrete base pavement was heard fifty feet away (how much farther it might have been heard was not determined) and was located exactly, saving nearly the cost of the geophone through not having to cut up the pavement. There was no surface indication of where the trouble was. It was only known that there was a leak in a certain block.

(2) A leaking half inch service in a 6-inch reinforced concrete pavement, 3½ feet deep, was located. Before starting, the suppositions were that a joint in a 16 inch main might be blown, or a valve was leaking, or a service had gone out. The geophone got on the job and left no doubt that a service was involved and located the exact spot at which to break through the pavement with a consequent saving in cost. It was only necessary to open the concrete pavement enough to permit a man to work.

(3) The local gas company was laying a main parallel to ours and discovered a considerable volume of water which was reported leaking from the water main. Inspection at fire hydrants, meter and valve boxes failed to disclose any leaks. The geophone was used showing no leaks whatever. Later it was proved that the water was ground water from a clayey soil.

The use of this instrument has been in the hands of Mr. Charles E. Moore, Assistant General Manager, and Mr. D. R. Taylor, Assistant Superintendent, of our Company, and I am indebted to them for the above data.

LABORATORY CONTROL OF WATER SUPPLIES AND SEWAGE TREATMENT, IN THE LARGE CITIES OF THE UNITED STATES IN 1920[1]

By Ira V. Hiscock[2]

History indicates that early health workers were primarily concerned with problems related to environmental sanitation. Improvement in water supplies and sewerage systems have thus been important factors in reducing the incidence of diseases spread largely through the alvine discharges. Cholera, for example, no longer menaces millions of homes and typhoid, which formerly took a yearly toll of 20,000 lives in this country, has been nearly wiped out. The bacteriologist, the chemist and the sanitary engineer all deserve credit for important achievements in these fields.

Today, city water supplies and sewerage systems are usually operated under special bureaus of the municipal government or by contract with private concerns, but the modern health officer maintains close contact with those directly responsible for these services. He is interested in an adequate and safe water supply and studies the laboratory reports of examinations, providing facilities for regular analyses if they are not available at the plant. As problems of sewage disposal have developed, the laboratory has also become an important factor in testing the efficiency of treatment methods and establishing modern methods of sewage purification.

A careful survey has recently been completed of municipal health department practice in 83 cities of 100,000 population and over in the United States.[3] This study includes data concerning the laboratory control of water supplies and sewage treatment which deserve

[1] Presented before the Division of Water, Sewage and Sanitation, American Chemical Society, New Haven, April 7, 1923. Printed here as original material of interest to our readers.—*Ed.*

[2] Assistant Professor of Public Health, Yale School of Medicine, New Haven, Conn.

[3] The writer desires to express his obligation to the Committee on Municipal Health Department Practice of the American Public Health Association, for permission to use the data upon which this report is based.

special consideration. It should be noted at the outset that it seemed advisable to limit the inquiry to the practice during the last current year for which data were available, and, as most of the surveys were made in 1921, the information obtained was for the year 1920.

WATER SUPPLY

According to the water supply[4] section of the report of the Committee on Municipal Health Department Practice, the public supplies of the 83 cities are for the most part derived from surface sources and are usually treated by chlorination as a final method, although the intermediate treatment processes vary considerably in different places. Only 9 cities, serving 4 per cent of the total population, use water without some form of treatment, 8 of these supplies coming from wells and the other from mountain streams. In 11 of the cities the water supply is owned by a private company, in 3 by a Metropolitan Board, and in the remaining 69 by the municipality itself. Practically all of the 83 cities either have a laboratory at the water plant or other arrangements for laboratory examinations.

Data available for 54 cities whose treatment plants were under technical control indicate that a laboratory was located at the plant in all but 9 cases. The water laboratory was usually in charge of a chief chemist with one or more assistants. The laboratory in Cincinnati, for example, employed in 1920 a chief chemist, a bacteriologist and an assistant with several helpers, while the laboratory in Toledo employed a chief chemist, 2 assistant chemists and 2 other assistants. In 35 cities of 100,000 population and over, whose personnel was classified in a way to furunish this information. (table 1), 84 chemists, bacteriologists and assistants were employed in the water laboratories, 32 of them serving 11 cities of 250,000 population and over.

These laboratory workers were specifically engaged in analytical work at the various water plants and had no connection, except coöperatively, with the bacteriologists and chemists employed in the public health laboratories who also systematically examined the water supplies in many of the cities studied.

It may be noted in this connection that information submitted by the public health laboratories of 64 cities shows, on the average, one bacteriologist to 145,000 people, or 8.2 bacteriologists per 100,000

[4] Freeman, Allen W., M. D., Water Supplies, A. J. P. H., 12: 9, 1922, p. 759.

total examinations; one chemist to 385,000 people, or 3.1 per 100,000 total examinations; and one assistant to 71,000 people, or 16.5 per 100,000 total examinations.

To quote from Dr. Freeman's interesting report on Water Supplies previously cited; "The degree of control exercised by the health department varies widely. In 31 cities no control is exercised by the municipal health department. In the case of 24 of these 31 cities, however, the state department of health maintains close supervision of municipal water supplies. This is notably true of cities in Massachusetts, Pennsylvania, Ohio, California, Michigan and Minnesota." In the remaining cities, control varies from absolute control in 3 cases to advisory supervision and coöperation, as illustrated in Atlanta, Cincinnati, New York and Richmond. In 3 cities, Jacksonville, Savannah and Syracuse, the health department makes all the water analyses. The water plant of the District of Columbia is under the control of the War Department.

TABLE 1

Table showing laboratory personnel of water supply plants, in 35 cities, 1920

CITIES OF POPULATION	NUMBER OF CITIES	BACTERIOLOGISTS			CHEMISTS			OTHERS			TOTAL PERSONNEL		
		Number	Per 100,000 population	Per city	Number	Per 100,000 population	Per city	Number	Per 100,000 population	Per city	Number	Per 100,000 population	Per city
500,000 and over	4	2	0.06	0.5	8	0.2	2.0	2	0.06	0.5	12	0.4	3.0
250,000 to 500,000	7	5	0.2	0.7	9	0.3	1.3	6	0.2	0.9	20	0.8	2.9
Less than 250,000	24	8	0.2	0.3	27	0.7	1.1	17	0.4	0.6	52	1.3	2.1
All cities	35	15	0.1	0.4	44	0.5	1.2	25	0.2	0.7	84	0.9	2.4

It would seem that most of the laboratories make both bacteriological and chemical analyses (including in some instances color, turbidity, total hardness, alkalinity, oxygen consumed and chlorine), although it has been observed that the scope of chemical analyses varies somewhat. In New York, physical and bacteriological examinations and free chlorine determinations are made daily, while complete chemical and microscopical examinations are made weekly. Data from 60 cities furnishing information on this subject indicate that bacteriological examinations of both raw and treated

water are reported made at least once a day in 47 cities, while chemical examinations are supposed to be made with similar frequency in 29 cities. It is interesting to find that the laboratories of the largest cities studied, as a rule, exercise the most careful supervision over their water supplies. Six of the cities listed as having examinations more often than once a day in the following table have populations of over 250,000 (table 2).

Nine of the cities not included in the above table are supplied with water from untreated sources, mostly wells. These supplies are examined from once, when the well is drilled, (Canton), to daily in Savannah. The stored supplies of 8 Massachusetts cities are examined monthly by the state. Syracuse and Rochester, N. Y., report biweekly examinations of their stored supplies, while the

TABLE 2

Table showing, by number of cities, the frequency of laboratory examinations, bacteriological and chemical, from different sources, 60 cities, 1920

SOURCE	MORE OFTEN THAN ONCE A DAY	DAILY	ONE TO FIVE TIMES A DAY	LESS OFTEN	NONE	TOTAL CITIES
Bacteriological:						
Raw	7	40	6	4	3	60
Treated	7	44	8	1	0	60
Chemical:						
Raw	6	23	7	16	8	60
Treated	8	25	6	15	6	60

San Francisco stored supply is tested monthly. For 3 cities we have no data on this question.

While information is lacking as to the exact number of water analyses of various kinds made on the average in a given year in these cities, rough estimates suggest that approximately 1000 bacteriological examinations and half as many chemical examinations would be about the figure for one of these large cities.

A study of the work of public health laboratories gives more definite information as to the water samples examined by the health department, and these data for 68 cities are contained in table 3.

From the above table it may be seen that the weekly number of laboratory operations of this kind vary on the average directly with the size of the city concerned. This is true for the total samples

and for both bacteriological and chemical samples, with the one exception of the proportionately small number of chemical examinations in the largest cities.

The presence of Bacterium coli in water with any degree of frequency is looked upon as possessing dangerous possibilities of intestinal diseases. According to the reports of 24 plant laboratories for which complete data on this subject are available (table 4), the results of treatment methods are for the most part quite satisfactory. It is surprising to find, however, that several of the large cities are unable to furnish adequate information concerning the results of laboratory analyses of their water supplies. In a few instances it was observed that the generally accepted Standard Methods[5] were not followed, while, in others, the difficulty of securing data was due to

TABLE 3

Table showing number of water samples reported by health department laboratories, 68 cities, 1920

CITIES OF POPULATION	NUMBER OF CITIES	BACTERIOLOGICAL		CHEMICAL		TOTAL	
		Number	Weekly per city	Number	Weekly per city	Number	Weekly per city
500,000 and over	12	18,571	29.7	1,584	2.5	20,155	32.2
250,000 to 500,000	13	6,739	9.9	4,604	6.8	11,343	16.7
Less than 250,000	43	19,629	8.7	11,360	5.1	30,989	13.8
All cities	68	44,939	12.7	17,548	4.9	62,487	17.6

failure on the part of laboratory workers to keep uniform records. Such conditions may be due in some instances to lack of sufficient personnel.

It may be observed in passing that all but two of the cities noted above use chlorination in some form for treatment purposes. Of these two, coagulation and settling methods are employed in Washington, where the results were negative in both 1 and 10 cc. amounts of the treated water tested. Fort Worth, the second of these cities in which chlorination was not used as a final treatment method in 1920, obtained from the slow sand filtration process negative Bact. coli results in 1 cc. amounts of the water on the average, and in all but 0.1 per cent of the samples in 10 cc. amounts.

[5] Standard Methods for the Examination of Water and Sewage, A. P. H. A., Boston.

It would seem that the treatment plants as a rule are under close laboratory control. This applies to all slow sand filters, all rapid sand filters except one, all coagulation and sedimentation plants and to a number of the well supplies and storage systems. The stored systems of Massachusetts are not usually under local control, monthly analyses by the state being deemed sufficient. There is apparent need, however, of greater standardization of technique in some of the laboratories and of better systems of recording and filing the results of routine examinations.

TABLE 4

Table showing, by number of cities, positive Bact. coli counts (by per cent) in raw and treated water supplies, 24 cities, 1920

PER CENT OF SAMPLES EXAMINED WHICH SHOWED BACT. COLI IN	NUMBER OF CITIES							
	1 cc. amounts				10 cc. amounts			
	Lake source	River source	Combination of sources	Total	Lake source	River source	Combination of sources	Total
Raw water:								
Less than 50 per cent	4	5	0	9	1	4	0	5
50 to 75 per cent	1	2	1	4	1	1	0	2
Over 75 per cent	0	10	1	11	3	12	2	17
Treated water:								
Less than 1 per cent	3	15	1	19	2	8	0	10
1 to 2 per cent	1	2	1	4	1	1	0	2
Over 2 per cent	1	0	0	1	2	8	2	12
Total cities	5	17	2	24	5	17	2	24

SEWERAGE AND SEWAGE DISPOSAL

Efforts to safeguard the quality of the water supply of a community by protective measures are often closely associated with problems of proper sewage disposal. Sometimes strips of land around reservoirs and streams have been purchased and cleaned, and sewage disposal works have been built to deal with the sewage of communities on the watershed. This, of course, represents only one of several reasons for proper sewage disposal systems and each community presents its own problem for solution.

The results of the study of methods of sewage disposal indicate that of the 83 surveyed cities, 61 dispose of their sewage directly by simple dilution into the nearest river or body of water. Of the remaining 22 cities which have some form of sewage treatment, 5 dispose of their sewage by dilution after passing through coarse screens. Excluding these 5 cities in which screening only is done, there remain 17 cities which operate more elaborate treatment plants designed to remove and digest the finer particles of suspended matter and to reduce the putrescibility of the sewage. Of these 17, however, the treatment works of six cities are designed to treat only part of the total sewage of the city. The type of supervision of these plants is illustrated in the following table (table 5).

TABLE 5

Table showing number cities having sewage treatment plants, laboratories at plants, and personnel, 83 cities, 1920

CITIES OF POPULATION	NUMBER CITIES SURVEYED	NUMBER CITIES HAVING TREATMENT PLANTS FOR		LABORATORY AT PLANT	
		All sewage of city	Part of sewage of city	Number of cities	Personnel
500,000 and over	12	1	1	1	Chemist, assistant, engineer, superintendent
250,000 to 500,000	13	1	1	1	Chemist, engineer
Less than 500,000	58	9	4	9	Bacteriologist, 8 chemists, 2 assistants, 3 superintendents, 2 engineers
All cities	83	11	6	11	1 bacteriologist, 10 chemists, 3 assistants, 4 superintendents, 4 engineers

All of the treatment plants are reported to be under the technical supervision of trained personnel, although there is no laboratory located at the plant in 6 of the cities, 3 of these being cities in which all of the sewage undergoes treatment. As indicated, the personnel in the above table applies only to the 11 cities having plant laboratories.

In conclusion, it should be borne in mind that the above summary of conditions in regard to both water supply and sewage disposal refers to the year 1920. At that time, new developments were in progress and have since materialized. It is believed, however, that the general picture fairly represents the stituation of the present day.

Regular chemical and bacteriological examinations of all public water supplies and of private wells and bottled waters should be made for the safety of the public. As suggested by the Committee on Municipal Health Department Practice,[6] if the public water supply is regularly and adequately examined in a laboratory attached to some other department of the city government, these tests may be omitted by the health department, but in such case provision should be made for the transmission of the results of such examinations to the health department. Furthermore, while the analytical methods of testing the performance of filters have not changed materially in the past two decades, new questions related to water purification have arisen as a result of the development of methods of determining the acidity of water in terms of hydrogen-ion concentration. This and other methods of physical chemistry have opened new fields of promise for research workers.

The necessity of technical supervision of sewage disposal and treatment methods should also be more fully impressed upon city officials. Laboratory analyses performed by skilled workers are essential in determining the type of sewage treatment which may be applicable to a given community, as well as in testing the efficiency of plants already in operation.

[6] Winslow, C.-E. A. and Harris, H. I., An Ideal Health Department for a City of 100,000 Population, A. J. P. H., 12: 11, p. 891.

REPORT OF COMMITTEE NO. 1 ON STANDARD METHODS OF WATER ANALYSIS[1]

Your Committee No. 1, to which is entrusted the work on the standardization of methods of water analysis, begs to report as follows:

During the current year we have had a definite proposal from the Laboratory Section of the American Public Health Association, asking us to cooperate with them in the preparation of the publication, Standard Methods of Water Analysis, which has in the past emanated from that Association. We were requested to state whether we would care to share, as the American Water Works Association, in the financial responsibility of the publication, and hence in the profits derived from the sale thereof. Definite instructions upon this matter have not as yet been received from the Standardization Council, but a copy of the letter from the Secretary of the Laboratory Section of the American Public Health Association was forwarded to the Council members.

In following out the idea of coöperation suggested by the Secretary of the Laboratory Section of the American Public Health Association, there was forwarded to the Chairman of your Committee No. 1, a statement covering all changes proposed in the revision of the Standard Methods of Water Analysis about to come from the press.

Upon receipt of this communication, and with the sanction of Chairman Harry E. Jordan of the Chemical and Bacteriological Section, a questionnaire was prepared and forwarded to all members of the American Water Works Association who were known to be specifically interested in chemical and bacteriological water examinations or interested in the Chemical and Bacteriological Section. A considerable number (58) of these questionnaires were filled out and returned to your Committee.

The changes which had been recommended by the American Public Health Association Committee for the Bacteriological Examination of Water are as follows:

[1] Presented before the Detroit Convention, May 24, 1923.

1. Elimination of the lactose litmus agar and the addition of eosine methylene blue agar for confirmation in the Bact. coli group.

2. Use of dehydrated media permitted, either Difco or any other brand giving equivalent results.

3. Elimination of the phenolphthalein titration of culture media and the approved indicators for the titration to be phenol red or brom thymol blue.

4. The number of colonies on plates to be counted to agree with numbers specified in the report on standard methods of milk analysis.

5. The lens used for counting colonies to have a focal distance of $3\frac{1}{2}$ inches.

6. The use of double or triple strength media to be permitted when large amounts of water are to be tested.

Presumably, these changes will mean that the completed test for organisms of the colon group would be as follows:

From the positive lactose broth fermentation tubes make one or more eosine methylene blue or endo agar plates, and fish at least 2 typical-appearing colonies, if such develop, and inoculate into lactose broth tubes and on to agar slant, examining these for gas-formers in the case of the broth tube, and for non-sporing bacteria in the case of the agar slant, after having incubated both at 37°C.

The "partial" test would seem to consist of noting whether the cultures on eosine methylene blue or endo agar plates carried organisms which appeared to be the Bacterium coli or its relative, the Bacterium aerogenes.

Those who returned the questionnaire, gave distinct approval to the proposed changes. (For changes, 42; qualifiedly for changes, 12; opposed, 2; no vote, 2.)

Some of the men reporting did not like to give up the use of lactose litmus agar, at least until they had had time to study the newer eosine methylene blue media. Your Committee would suggest that the objection to the use of eosine methylene blue agar in these few cases might have been due to a typographical error in one of Levine's papers which gave the amount of methylene blue to be used just four times as great as intended. This incorrect formula gives a blue plate instead of one having a claret color. The use of saccharose might also have caused difficulty.

It was also felt that, if the dehydrated media should be permitted to be used, they should be prepared always in strict conformity with formulae of the Standard Methods of Water Analysis. Dissatis-

faction with some of the dehydrated media on the market was expressed because the endo media did not give entirely satisfactory results, and because the eosine methylene blue media contained saccharose.

In a few instances the abandonment of the phenolphthalein titration was opposed on account of its general use in the past.

Water analysts seem to be divided into two distinct schools of thought with regard to the examination of water for organisms of the colon group. One school wishes a narrow definition of the colon group which will exclude as many of the atypical fermenters as possible, and which will attempt definitely to eliminate those which are not members of the fecal type of organisms, upon which they think greatest emphasis should be placed. The other school wishes a broader definition of the colon group with simpler and more rapid test, adapted to routine work, involving smaller amounts of equipment and less thoroughly trained personnel.

The vote for the making of confirmatory tests on all fermentation tubes which give positive presumption tests is nearly 2 to 1 in favor of the proposition. (For, 36; against, 19.) Those who oppose the idea feel that it is unnecessary in routine work, and that a larger number of samples less rigidly examined are more valuable than a smaller number of more carefully confirmed examinations. Several of those who do not favor checking of the positive results, apparently are not bothered by many spore-forming lactose-fermenters in their raw water.

Apparently the idea is general that the completed test as outlined above is sufficient for all needs, except those of a research character. For routine, simpler tests are frequently used. (Vote for detailed tests, 16; against, 34; qualifiedly for, 6; not voting, 4.)

The methyl red and Voges-Proskauer tests are the most popular secondary tests for the colon group confirmation after the recommended eosine-methylene blue or endo agar smears and the agar slant test for spore-forming organisms. Your Committee would emphasize the fact that the methyl red and Voges-Proskauer tests were intended for pure culture work, and not for work on mixed cultures such as would be obtained by the inoculation of material from the positive broth or bile tube directly into Clark and Lubs' medium. Conflicting reports on the accuracy of these two tests have been obtained by some water bacteriologists, and your Committee would advise that, if these tests are to be used with confidence, preliminary

purification must be carried out. This involves a greater amount of time before results may be obtained and this, it must be realized, materially decreases the value of the tests as routine procedure.

In the case of the Koser uric acid test, the objections raised are that the period of incubation is too long and the difficulty of preparing the medium is too great, including as it does the necessity of avoiding nitrogen compounds other than the uric acid. This test, for reliable results, should, like the methyl red and Voges-Proskauer tests, be made only upon pure cultures. A few laboratories report good results with the medium.

The indol test, as well as those for gelatine liquefaction and the fermentation of saccharose, have each a few advocates. Of the three, the indol test is the most popular. The objection to these tests rests chiefly on the fact that they are not at present on a sufficiently definite basis. Adonite is too expensive.

The Weinzirl or Botkin test for spore-forming lactose fermenters (and Clostridium welchii) seldom seems to be made. The general opinion is that these organisms cannot, at least at present, be regarded as having any sanitary significance. The data so far obtained, and recalling the presence of the organisms in milk, on grains, etc., do not warrant any change in the opinions concerning the sanitary significance of spore-formers and the Clostridium welchii given in the symposium in the Engineering News-Record for June 2 and 9, 1921.

The question as to whether lactose broth or lactose bile is the preferable medium for preliminary enrichment is still unsettled. Each has its supporters. Lactose brilliant green bile has a number of advocates.

The Hall-Ellefson or Wagner-Monfort gentian violet broth has not been used very widely. In one laboratory, where spore-forming lactose fermenters are frequently found in 10-cc. plantings, the the gentian violet broth has usually eliminated the spore-formers. Apparently it has also a decidedly inhibitory effect on the Bacterium aerogenes. On long incubation the color is destroyed or precipitated and the culture develops gas which in a few cases has been found due to the Bacterium aerogenes.

Another laboratory reports the successful use of a fuchsin broth for inhibiting non-confirming lactose fermenters.

There is a general, and undoubtedly justified, feeling that many of the special methods and the special media which have been proposed

have not had all of the study which they need to place them firmly on a basis which justifies their being used as standard procedures. Further study should naturally be encouraged in order to learn the value for research and routine purposes of the more promising proposed media and methods.

The manner in which the reporting of the results on the fermentation tubes is carried out has been given considerable study in the last few years. In replying to the questionnaire about one half of the 58 workers stated that they used the Phelps B. coli index. The usual reasons are the ease with which the values are obtained and the fact that it has been so generally employed elsewhere. A few men prefer the McCrady or some other method or reporting the most probable number of Bacterium coli per unit volume of water. The rest prefer to report the presence or absence of the organisms in a definite quantity of water or to report the percentage of positive tubes in the different dilutions employed.

Regarding the interpretation of the results of examinations of treated waters, when spore-forming organisms are present, the majority (41) seem to feel that the spore-formers are not of importance, at least in the present state of our knowledge. A few (4) consider the spore-formers to be significant, and two consider that they are important indicators of contamination under some conditions.

The attempt to split the colon group organisms into the fecal and non-fecal members and to place emphasis on the organisms of the fecal group as distinguished from the non-fecal forms does not find favor with those who answered the questionnaire. There are a few (6) who do feel that the test is of value at the present time.

The status of the attempt to give difference of interpretation to the Bacterium coli section of the colon group and the Bacterium aerogenes section of the group is about the same as the status of the fecal and non-fecal groups, so-called. Attention has been directed by some to the fact that the Bacterium aerogenes may multiply in chlorinated waters, and to the fact that it should seem to have special significance in untreated surface waters, since it is more typical of surface wash than of sewage.

A short résumé of the opinions disclosed by the questionnaire follows:

1. The changes reported by the secretary of the Laboratory Section of the American Public Health Association are generally approved.

2. As at present understood, the supplementary tests not contained in the "completed test" are undesirable in routine. (Further study of the greater number of them, in particular the inhibitory broths and biles, is needed. The study should include a wide range of territory and types of supplies.)

3. We are not justified, on the basis of our present information, in attaching special importance to spore-forming lactose fermenters in treated waters.

4. Our present knowledge does not warrant our attempting to place any great faith in the lack of significance of "non-fecal" members of the colon group. The "non-fecal" members of the group should be interpreted in the same manner as the "fecal" group when found in treated waters, except, perhaps, in a few instances where special detailed knowledge of the case is available.

Your Committee is of the opinion that the above statement represents fairly accurately current practice and opinion among the members of this Association and in the water supply field.

Regarding the proposal that an arrangement be entered into by the Association and the American Public Health Association by which the two Associations would be jointly responsible for the publication and preparation of the Standard Methods of Water Analysis, your Committee is of the opinion that such an arrangement by all means should be entered into if feasible and capable of being carried into execution.

Respectfully submitted,

E. M. Chamot,
McHarvey McCrady,
Lewis I. Birdsall,
Abel Wolman,
H. W. Clark,
Wm. Mansfield Clark,
Max Levine,
Jack J. Hinman, Jr., *Chairman.*

REPORT OF COMMITTEE NO. 2 ON REVISION OF STANDARD SPECIFICATIONS FOR CAST IRON PIPE AND SPECIAL CASTINGS[1]

The work of your Committee during the past year has been largely confined to a consideration of the results of the second series of test bars, cast from special metal at a representative northern and southern foundry, as reported by Dr. Moldenke to the Foundrymen's Test Bar Committee.

Before discussing the findings of Dr. Moldenke it may be well to restate briefly the position of your Committee in reference to test bar requirements.

In the tentative draft of Revised Specifications, issued in 1916, a specification of the chemical qualities of the metal had been included, and had at once met with strong opposition from the manufacturers. As an alternate method of protection against unsound and non-resilient iron your Committee then concluded to lay more stress on the requirements of a progressive relation between deflection and load in test bars, and in 1922 these requirements had developed to the following form:

Specimen bars of the metal used, each 26 inches long by 2 inches wide and 1 inch thick, for determination of transverse breaking load and deflection, shall be made without charge as often as the engineer may direct, and in default of definite instructions, the contractor shall make from each heat, or run, two sets of test bars—the first taken from the second ladle after starting cupola and the second from the last ladle poured before end of heat. Where the heat exceeds 25 tons, an additional set of test bars shall be made for each additional 25 tons or fraction thereof. Each set shall consist of three bars, which shall be cast vertically in dry sand—with top pour—by dipping from full ladle between cupola and pipe floor. Bars shall be brushed and not rumbled before testing.

The bars placed flat wise on supports 24 inches apart shall be tested transversely to destruction by centre load applied at such speed as will give 20 to 40 seconds for each 0.10 inch increase in deflection, and under these conditions shall develop a breaking load of not less than 1900 pounds with a deflection at this load of not less than 0.30 inch. For bars breaking at higher loads there

[1] Presented before the Detroit Convention, May 24, 1923.

shall be an additional deflection at the breaking point equivalent to 0.025 inch for each 200 pounds of breaking load above 1900 pounds.

The successful fulfillment of this breaking load-flexure test by one bar of each of the two sets of test bars—above specified—shall be accepted as sufficient proof of the physical quality of the metal; failure of all three bars of both sets shall give cause for rejection of the pipe made from the heat from which the test bars were taken.

The difference between the foregoing specification and that for test bars in the present American Water Works specification is that, by the proposed revision, deflection must increase with the breaking load, while under the present requirements of at least 1900 lbs. breaking load and 0.30 inch deflection at some load not specified, it is possible to run up the strength at the expense of deflection.

The objective of the investigations undertaken by Dr. Moldenke, and generously financed by the manufacturers, has been to test the feasibility of the definite relation between load and deflection proposed by your Committee.

As stated in our report of last year, the first series of tests of bars cast from the regular run of metal in eight different foundries showed that a large percentage of the iron represented by these bars would have been condemned, if subjected to the test bar specification proposed by your Committee.

The object of the second series of tests was to determine whether by changing the cupola mixes, an iron capable of meeting the proposed test bar requirements could be produced within commercial limits of cost. Unfortunately, the results of this second series of test bars, made from "ordinary rich pig mixtures," have proved less satisfactory than those of the 1921 series cast from the regular run of metal in the foundries, and while in the first series the average of all bars showed a breaking load of 2080 lbs, and a deflection at breaking of 0.358 inch, the corresponding results in the second set were a breaking load of 1995 lbs., and a deflection of 0.301 inch, and less than half of the bars would have met the present specifications of 1900 lbs. breaking load and final deflection of 0.30 inch. Evidently therefore, the foundrymen are to be credited with skilful supervision of the regular run of cupola mixes, and nothing is to be gained by the use of such "ordinary rich pig mixtures" as were used in the investigation of the past year. This inference however, does not deny the possibility of producing by improved foundry practice, and within reasonable limits of cost, a metal which will at least require no reduc-

tion in the present specifications which have been so generally complied with in the past. It is admitted that there are certain conditions in the quality of the coke obtainable particularly during and since the war, and in some cases in the overdriving of cupolas, which might be changed to the benefit of the product.

Dr. Moldenke from his investigation finds that, to enable 75 per cent of the bars tested by him to pass, the deflection at 1900 lbs. load would have to be lowered to 0.22 inch. Your Committee cannot accept this deflection as a reasonable basis for the revision of specifications. As Dr. Moldenke remarks in his report "the thought cannot be escaped that the pipe industry is subject to a possible improvement in the practice of some of its component members," and an examination of the results obtained in the investigation makes evident the fact that it is the failure of some of these component members to maintain a certain standard, which brings down the average test bar load and deflection to the level suggested by Dr. Moldenke as a basis for the test bar specifications.

Your Committee is of the opinion that the irons tested by Dr. Moldenke are somewhat lower in average strength and substantially lower in average deflection than those produced at the time the original specifications were written and for some years thereafter. In particular is this conclusion indicated by the comparative results obtained by Mr. T. H. Wiggin, a member of the Committee, in his work for the Metropolitan Water Board of Massachusetts, during which more than 3500 test bars representing more than 35,000 tons of pipe were broken with the utmost care and refinement in observation. The average breaking load found by Mr. Wiggin equalled 2190 lbs. and the average deflection 0.385 inch which, when compared with the results obtained by Dr. Moldenke in 1921 and 1922, clearly point to lower average strength and deflection in the present iron tested as compared with those obtainable in past years. In the light of this apparently justifiable conclusion your Committee now finds itself unable to accept the results disclosed by Dr. Moldenke's tests as a basis for revised test bar specifications. To do so would be to fit the specifications to the material now being produced, which in average strength and deflection, as indicated by the test bars, is inferior in quality to that obtainable in the years, when the greater part of the pipe, on which our experience of breakage after laying is based, was manufactured.

The test bar, whether logically or not, provides at the present time the only direct measure of the quality of the metal in the pipe. Resiliency is an important factor, and while the Committee is unable to demonstrate that 0.30 inch deflection at 1900 lbs. is the necessary minimum, it is unwilling, without further investigation, to adopt a lower figure.

In our opinion the development of a specification which will guarantee metal of the highest quality obtainable, within reasonable limits of cost, is a necessary preliminary to and more important than the reclassification of present standard weights, and it is our judgment that revision of the present specifications may well be postponed until this phase of the problem is more nearly solved. Whether chemical requirements should be included in such a specification, whether the deflections proposed by your Committee are reasonable and necessary, whether finally the test bar is the best method of measuring the physical character of the metal in the pipe, are all moot questions which demand consideration.

It is of interest to note that Mr. Brush, a member of the Committee, has for some years specified a deflection of 0.30 inch at 2000 lbs., and a flexure increment of 0.03 inch for each 200 lbs. of additional breaking load. It is the hope of the Committee that by study of the future results obtained under this specification, Mr. Brush will be able to furnish information which will indicate whether the test bar requirements proposed by your Committee are justified and possible of fulfillment.

Your Committee appreciates the fact that the relation between load and deflection may not be finally justified and realizes that a more direct test of the metal in the pipe, than is furnished by the vicarious test bar, is highly desirable. In the case of centrifugally cast pipe, narrow rings cut from the spigot end and subjected to compression apparently promise a practicable means of directly measuring the physical qualities of the pipe. It may be that this method can be used with pipe cast in the ordinary way and the foundrymen will try out this ring test in comparison with standard bars during the coming year.

Dr. Moldenke has recommended the establishment of a continuing bureau of research by the foundrymen, with coöperation by a committee of engineers. It is only by some such continued investigation that the problem of determining the minimum requirements in quality of output and the development of the foundry practice necessary to

meet such requirements with reasonable uniformity can be solved, and to the recommendation of Dr. Moldenke we accord our hearty approval.

At the meeting of your Committee with the producers in April, the manufacturers agreed to submit within six months a tentative draft of revised specification based on that proposed by your Committee in 1916. This will serve definitely to record in parallel any difference in the viewpoints of the manufacturers and of the Committee.

The American Engineering Standards Committee has recently taken up the task of standardizing cast iron pipe. The Chairman of your Committee has accepted a place on the American Engineering Standards Committee as a representative of this Association.

In closing, we wish to acknowledge our obligations to the manufacturers for their generous coöperation, and to express our appreciation of the work done by Dr. Moldenke.

Frank A. Barbour, *Chairman*,
Walter Wood,
Edward E. Wall,
N. F. S. Russell,
William C. Hawley,
William W. Brush,
Thomas H. Wiggin.

FINAL REPORT OF COMMITTEE NO. 14 ON STEPS TOWARD STANDARDIZING STATED QUANTITIES FOR SLIDES IN METER SCHEDULES[1]

Your Committee, on May 19, 1922, presented its preliminary report,[2] in which was incorporated tentative recommendations for a standard form for meter rates. Prior to the preparation of the preliminary report, your Committee reviewed the work of the Committee on Meter Rates of the New England Water Works Association. This Committee had made an exhaustive study of the whole field of meter rates, and in February, 1916, had reported[3] to the New England Water Works Association, recommending the adoption of a form of rate schedule, containing a service charge and three steps or slides. In November, 1916, the report was adopted and has been the standard of that Association to the present time. The forms for the schedules, as recommended, are given in detail in our preliminary report.

This form of schedule, identical with the standard of the New England Water Works Association, has been adopted by a large number of water works systems. A list of the cities or works known to have adopted it was given in our preliminary report. The total population served under this form of rates aggregated, at that time, about two million. Your Committee wrote to representatives of these works to obtain the benefit of their views based upon practical experiences with this form of rate schedule. Replies from these representatives in all cases expressed general satisfaction with the schedules, both from the standpoint of the utility and the consumer, and no radical changes were suggested. There were several suggestions to incorporate in the schedule a fourth or lower rate for large manufacturers.

Your Committee obtained the views of each member of the former Committee on Meter Rates of the New England Association as to

[1] Presented and accepted before the Detroit Convention, May, 1923.
[2] This Journal, Vol. 9, July, 1922, page 636.
[3] Journal N.E.W.W.A., Vol. 30, Sept., 1916, page 361.

the desirability of making any changes in the former recommendations. No important changes, however, were suggested.

There are about as many different ideas on the proper form of rate schedule as there are contributors on the subject. It is obvious that no two persons, or group of persons, working independently would arrive at the same conclusions as to the number of slides to be incorporated in the schedule, or as to the stated quantities in each slide. The New England standard form is a three rate schedule, the rates, for convenience, being called first, the Domestic Rate; second, the Intermediate Rate; and, third, the Wholesale or Manufacturing Rate. The quantities allowed under each rate may be summarized as follows:

	(1) AT DOMESTIC RATE, FIRST	(2) AT INTERMEDIATE RATE NEXT	(3) AT MANUFACTURING RATE, ALL OVER
Quantities in gallons			
Bills annually	300,000	2,700,000	3,000,000
Bills quarterly	75,000	675,000	750,000
Bills monthly	25,000	225,000	250,000
Quantities in cubic feet			
Bills annually	40,000	360,000	400,000
Bills quarterly	10,000	90,000	100,000
Bills monthly	3,300	30,000	33,300

The quantity of water covered by the first or Domestic Rate will include substantially all water used by private residences, and also much of the water used by small commercial and industrial establishments. Your Committee, in presenting its preliminary report, could see no good reason to make any changes in the quantities above listed, which are convenient in application, whether billed in gallons or in cubic feet.

As previously stated, schedules in the above form have been adopted by many works, and have been satisfactory. The form is becoming more generally recognized as standard. Nothing would have been gained by the adoption of different standards by the two largest water works Associations. Your Committee, therefore, in its preliminary report, incorporated practically *in toto*, the standard

form of schedule as adopted by the New England Water Works Association, using the same quantity slides. The only changes were an improvement in the form of statement, and the inclusion in the schedule, under certain conditions, of a fourth rate, to be known as the Special Rate, which should apply only to quantities in excess of 30 million gallons per annum, equal to 2½ million gallons per month, or to 4 million cubic feet per annum, one million cubic feet per quarter, or 333,300 cubic feet per month. This was following a tentative recommendation in the preliminary report of the New England Committee, not incorporated in their final report. Your Committee is of the opinion that under certain local conditions, in plants supplying large industries, a fourth special rate of this character is desirable, in order to encourage the liberal use of water for manufacturing purposes and to attract new enterprises.

The following are the forms for the schedules, as recommended. They are given in alternate forms according to whether gallons or cubic feet are used. The monthly unit of time is used as an example. It will be noted that the average daily quantities of water in each class are unifrom throughout.

Quantities in gallons—bills monthly

Service charges

SIZE OF METER	MONTHLY CHARGE	SIZE OF METER	MONTHLY CHARGE
⅝ inch or less..........	$..........	3 inch..................	$..........
¾ inch..................	....	4 inch..................	....
1 inch..................	....	6 inch..................	....
1½ inch..................	....	8 inch..................	....
2 inch..................	....	10 inch..................	....

For water delivered in addition to the service charge, there shall be a charge for all water delivered, as follows:

For the first 25,000 gallons per month....$——— per 1000 gallons
For the next 225,000 gallons per month....$——— per 1000 gallons
For all over 250,000 gallons per month....$——— per 1000 gallons

Where the fourth or special rate is used, the schedule will be as follows:

For the first 25,000 gallons per month $——— per 1000 gallons
For the next 225,000 gallons per month $——— per 1000 gallons
For the next 2,250,000 gallons per month $——— per 1000 gallons
For all over 2,500,000 gallons per month $——— per 1000 gallons

Quantities in cubic feet—bills monthly

Service charges

SIZE OF METER	MONTHLY CHARGE	SIZE OF METER	MONTHLY CHARGE
⅝ inch or less..........	$.........	3 inch................	$..........
¾ inch or less..........	....	4 inch................	....
1 inch or less	....	6 inch................	....
1½ inch or less	....	8 inch................	....
2 inch or less..........	....	10 inch................	....

For water delivered. In addition to the service charge, there shall be a charge for all water delivered, as follows:

For the first 3,300 cu. ft. per month...$——— per 100 cubic feet
For the next 30,000 cu. ft. per month...$——— per 100 cubic feet
For all over 33,300 cu. ft. per month...$——— per 100 cubic feet

Where the fourth or special rate is used, the schedule will be as follows:

For the first 3,300 cu. ft. per month...$——— per 100 cubic feet
For the next 30,000 cu. ft. per month...$——— per 100 cubic feet
For the next 300,000 cu. ft. per month...$——— per 100 cubic feet
For all over 333,300 cu. ft. per month ..$——— per 100 cubic feet

The above schedules were presented as the tentative recommendations of your Committee in its preliminary report. It was urged that the preliminary report be made the basis of discussion by members of the Association, in order to obtain divergent views, and ascertain if possible, through general discussion, if there were any valid objections to the form of schedule recommended. The report brought forth some discussion on rate matters in general, but there was but little on the form of schedule. There was no adverse comment.

The original and particular purpose of your Committee, according to its own interpretation, was limited to the question of setting up a form of meter rates which could be adopted as a standard by the American Water Works Association and recognized as such. This could not be accomplished without a more or less complete investigation of the whole field of meter rates, and your Committee accordingly asked and was empowered to extend its scope as far as necessary.

There is a wide divergence of views among water works operators as to the best basis for calculation of water rates to distribute the burden equitably among all classes of consumers.

Your Committee does not feel that it is advisable or necessary for it to enter this discussion. Much has been written on this subject and

the excellent work of your Committee on Private Fire Protection, whose report is found in the JOURNAL, volume 6, page 679, 1919, constitutes one of the most thorough and exhaustive discussions yet presented on this subject.

What the Committee now wishes to emphasize is that, whatever decisions may be reached as to these matters, the form of rate now proposed is sufficiently flexible to permit reasonably accurate expression of any views that it may be desirable to express in water rates, and that it meets all required conditions as well as it is possible for any reasonably simple form of rate to do.

In fixing rates under this schedule these matters must be determined; *first*, the amount of revenue to be raised, or, in other words, how high the general scale of rates must be. *Second*, the amount of spread; that is to say the ratio between rates given to the smallest and largest takers; and, *third*, the proportion of the total revenue to be raised from service charges, and the most equitable means of its distribution. Flexibility in these determinations gives all needed latitude in adjusting rates to what may be considered equitable for each class of takers.

Your Committee, therefore, submits the forms for the schedules as given in its preliminary report and listed in detail above, as its final recommendations, and asks that they be adopted by the Association as its standard form of meter rates.

By the above action, the standards of both the American and New England Water Works Associations will be identical, which will accomplish the greatest good, and tend to eliminate doubt and confusion in the minds of operators contemplating a revision of their rate schedules.

The benefits to be derived from a simplified and standard form of meter rates are so manifest that detailed discussion would appear unnecessary. Many superintendents of plants, laboring under complex meter schedules with many steps, to which is frequently added the burden of flat rates with a multitude of different items, will find the suggested form of rate a great boon. Much time will be saved in the work of accounting and billing. Many complaints due to misunderstandings incidental to complicated schedules should be eliminated. It will be possible to compare intelligently water rates of different cities, which is practically impossible under present schedules.

One of the most important points to be considered in the question is the attitude of regulating bodies. In many states no changes

in the rate structure are permitted without the prior approval of the Public Service Commission. In the hundreds of rate adjustments during the past four or five years, there are only a few where the new rates have been made upon scientific lines. In a number of cases which have come to the attention of your Committee, the Commissions have taken upon themselves the framing of the quantity slides and have added additional slides in the rate schedules. Your Committee respectfully presents that it is the province of water works engineers to work out their own forms of rate schedules. The Commission may then fix the actual rates to be applied under the Standard Schedules.

As stated in our preliminary report, it is the opinion of your Committee that probably the greatest benefit which will result from the adoption of a standard form of rates, is the simple fact that it is a standard, approved and in form recommended by the leading water works associations. Rates in the suggested form have already been approved by several State Utility Commissions, and others will undoubtedly follow. As a more or less universal and established procedure, therefore, it must be received and accepted by water consumers as a recognized standard, and should thus eliminate to a great extent the misunderstandings and opposition instituted by many communities, particularly on the question of service charges.

CHARGES IN THE SCHEDULE

Up to this point we have not discussed the rates or charges in the schedule. The schedule does not fix these rates. They are left to be fixed for each case as may be necessary to produce the required revenue. In the general application of unit prices of the steps of the schedule, your Committee holds to its recommendations in the preliminary report, which are also in accordance with the New England Association standard, and are briefly as follows:

That the price per 1000 gallons or per 100 cubic feet be, wherever possible, an even number of cents, omitting fractions.

That the Intermediate price for water be to the nearest cent midway between the average and the mean proportional of the domestic and the manufacturing rate. By this rule the intermediate rate is definitely fixed at an amount halfway between the two, or halfway between the two less one-half cent. This may not be a strictly scientific adjustment, but it would appear to be as satisfactory a

procedure as could be selected. Consideration may thus be concentrated on the proper charges for the domestic and manufacturing rates.

In regard to the amount of slide in the schedule your Committee is of the opinion that the ratio between the domestic and manufacturing rates should not be excessive, and should be limited to about 2 to 1. It is also suggested that in cases where the fourth or special rate is used, the amount of slide between the first and fourth rates should not exceed the ratio of 3 to 1.

Your Committee recognizes, however, that there can be no hard or fast rule which can be applied to all cases. We have endorsed the sliding scale principle, up to the limits of slide above recommended, and are of the opinion that such slides are not discriminatory, but are fully warranted to cover the extra cost of distribution to small takers. It is sometimes claimed that all of these additional costs to the small user should be made up in the service charge, and that the price of water used should be the same to every one. The principal reason for slide in the schedule is the greater investment in street mains supplying small consumers, in individual service lines and meters, and the additional cost of meter readings, billing and collecting.

In certain municipal plants where it is the practice to require consumers to pay for the water mains according to frontage, install their own service lines and meters and repair the same, the reasons for the sliding scale are largely removed. In such cases a uniform rate per thousand gallons to all consumers, in addition to the service charge may be satisfactory. This is not a case where the proposed form of rate does not apply. It is instead a special case in that the slide ratio between the highest rate and the lowest rate is reduced to one and the rates for all classes are made the same. In the case of a privately owned utility, however, required under Public Utility rulings to install at its own expense all mains, services and meters, and keep the same in repair, if attempt is made to include all these costs in the service charge, and a correspondingly low rate for water, this condition would approach the flat rate basis of charge and nullify, to a large extent, the benefits of metering. In such cases, therefore, the better practice is to adopt a service charge lower than the entire cost of readiness to serve, and to use the sliding scale to distribute the remainder, as nearly as possible, where it should fairly go.

Your Committee deems it inadvisable in this report to discuss in detail its opinions as to just how to determine these charges. It

fears this would befog the issue, and possibly defer the adoption of the standard form of schedules, which is considered to be of greatest importance.

In our preliminary report questions pertaining to the sliding scale, service charges, minimum rates and principles involved in the determination of rates were discussed at some length. Members are referred to these discussions, and they will not be repeated here.

Your Committee would also recall the attention of members to the following recent papers on rate matters which are worthy of study.

Report of Committee on Private Fire Protection, J. A. W. W. A., November, 1919, p. 736.

Municipal Water Rates, by Bankson, Davis & Finley, J. A. W. W. A. September, 1921, p. 497.

Water Rates, by Nicholas S. Hill, Jr., A. W. W. A. Convention, 1921.

Water Rates, Discussion, Allen Hazen, J. A. W. W. A., May, 1922, p. 528.

Water Rates, by J. O. Craig, J.A.W.W.A. March, 1923, p 2.65.

The Propriety of the Service Charge for Water Service, By George W. Biggs, Jr., Proceedings of the Pennsylvania Water Works Assn., 1921, p. 193.

Meter Rates for Detroit, by George H. Fenkell, City Document, 1923.

Meter Rates for Water Works, by Allen Hazen, John Wiley & Sons, 1918.

In the papers by Messrs. Bankson, Davis and Finley, and by Mr. Biggs, the principles of establishing a scientific schedule of rates are discussed at length, and concrete illustrations are given showing methods for apportioning the charges for water services.

In practically all recent writings, the service charge is generally recognized as the best solution yet devised for distributing that part of the burden which it represents.

Many Public Service Commissions have given preference to such a charge rather than the meter minimum. There is unfortunately a common public misunderstanding of the service charge. Where utilities are contemplating a change in their rate schedules, an effort should be made to inform their consumers what the service charge is and why it should be incorporated in the schedule. It should be explained that it is not an attempt to extract more revenue from them, but rather to establish their charges on a fairer and more equitable basis; that the utility must have sufficient earnings to pay its way and earn a fair return on invested capital, regardless of whether its schedule contains a service charge, minimum charge or any other form of rate; that the service charge is not a charge of three or six dollars or more a year for a meter that costs ten or twelve dollars, which is the

popular misconception, but rather that it is a fair charge for the cost of keeping the plant in readiness to serve him at all times, and pay interest on capital invested to serve him. The average consumer, where service charges have been instituted, believes he is paying for something which he does not get. If a serious attempt is made to enlighten him, it can be readily shown that it actually does cost the utility real money to have water on tap at high pressure for his service even though he does not use a drop of water, and that it is this readiness to serve cost, or at least a portion of it, which is represented by the service charge. With this fact admitted, he can then be shown that he is paying for exactly what he uses, and that, on the contrary, under the minimum basis, he is being grossly discriminated against.

The service charge seems to be the point upon which public opposition has centered. This opposition has occurred not only in water works, but also in the gas industry. To overcome this objection a number of gas companies have devised a form of rate, in which the service charge is buried in a higher charge for the first small block of one hundred cubic feet of gas. For instance, assuming a monthly service charge of 50¢ and a $1.10 gas rate, this scheme would result as follows:

Service Charge	$0.50
Gas	.11
Rate for first block of 100 cu. ft.	0.61
Rate for next block per 1000 cu. ft.	1.10

This scheme is a subterfuge, and your Committee does not approve of its application to water rates.

The term "Service Charge" has probably had something to do with the objections against it. If the service of the utility has suffered interruptions and is not up to the usual standard, the consumer may feel that in the payment of the service charge, he is being charged for something he did not get, namely good service.

One case has come to the attention of your Committee, of the water rates at Daytona, Florida, where the service charge is called by another name. It appears in the schedule as follows:

Annual Maintenance Fee for ¾ inch service	$5.00
Annual Maintenance Fee for 1 inch service	7.00

It would appear to your Committee that this form of expression has some merit, and sees no reason why this expression should not be adopted, if it will make it easier of adoption under any local conditions. This change will not affect the form of rate recommended and simply means the substitution of one term for another.

Mr. Biggs, in his paper on the propriety of the Service Charge for Water Service, presents a clear cut illustration of the discrimination under a minimum charge, and its elimination under a service charge, which is worthy of repetition here. To quote from Mr. Biggs' paper:

> Assume a minimum for a $\frac{5}{8}$ inch meter of $1.25 per month and a charge for say the first 10,000 gallons of water a month, or less, of 30 cents per thousand gallons. Let us then assume four consumers, A, B, C and D, supplied through $\frac{5}{8}$ inch meters. A used 1000 gallons of water during the month; B, 2,000 gallons; C, 3000 gallons and D, 4000 gallons. Each of them, under the minimum basis of charge, pays $1.25, notwithstanding that D used four times as much water as A. Under such possibilities, how can anyone successfully defend the charge of discrimination?
>
> The service charge, on the other hand, eliminates this discriminatory feature, as the water consumer pays for just the quantity of water he uses. Again take the four consumers A, B, C and D, and assume a monthly service charge of 75 cents and a rate for water of 20 cents per 1000 gallons. A would pay 95 cents; B, $1.15; C, $1.35, and D, $1.55 per month. The water company would receive from the four consumers $5.00 a month, according to each method of charge; but the element of discrimination is avoided by the last method.
>
> Instead of the popular objection to the service charge which now generally prevails, the consumers, if the logic and advantages of the service charge were properly explained, would, it is believed, favor it. From the standpoint of the consumer the service charge affords an incentive to conserve the use of water, yet permits of decreasing the rate for water, so that he need not be niggardly in its use.

It is a matter of gratification to the members of your committee that rates conforming wholly or in part to the standards set forth in its preliminary report, and now recommended for adoption by the Association, have been adopted during the past year by several important water works systems. These include Norfolk, Virginia, where the service charge is adopted in the new rates, but without following the exact classification of water quantities, and Providence, Rhode Island, where the classification of quantities is followed, but with a minimum instead of a service charge. Two large systems have adopted the complete standard. These are the East Jersey

Water Company and its subsidiaries supplying part of the New Jersey Metropolitan District, and the City of Detroit which has adopted rates in standard form, to become effective July 1, 1923. These systems, in addition to those enumerated in the committee's preliminary report, will bring the population served by works using meter rates in standard form to over three million people.

Respectfully submitted,

ALLEN HAZEN, *Chairman*,
ISAAC S. WALKER, *Secretary*,
THEODORE A. LEISEN,
BURTON LOWTHER,
GEORGE N. SCHOONMAKER,
Committee.

ARTHUR E. BLACKMER,
Representative of the New England Water Works Association.

CYLINDER OIL SAVED IN ST. LOUIS WATER DEPARTMENT BY USE OF IMPROVED FORCE FEED LUBRICATORS[1]

By Leonard A. Day[2]

On all the main pumping units and principal auxiliaries at the St. Louis Water Works previous to April, 1922, Type "M" Richardson Lubricators were used. In this type of lubricator, the oil flows by gravity, or under a slight pressure to the needle valves, where the rate of flow is adjusted through the sight feed glasses. It was found that, when the needle valve was adjusted for an economical rate of flow, a triple filtered oil was necessary to prevent clogging. This tendency to clog was usually taken care of by giving the needle valves a wider opening, thus increasing the flow of oil.

Type "T" Richardson Lubricators were installed on all feeds on the above date and have been in constant service since. The rate of flow in this type is controlled by the length of stroke of the pump plunger, instead of a needle valve. The ports and channels for the flow of oil remaining the same for all rates of flow. The tendency to clog is less and a cheaper oil of the same flash point may be used.

During the last year of operation of the old type lubricator, 6682 gallons of oil were used at 56 cents per gallon, and for the same service, but with an increase in pumping, 5997 gallons were used at 31 cents per gallon, a saving in oil of 685 gallons and in cost of $1882.85.

[1] Prepared under the auspices of Committee No. 7, on Pumping Station Betterments.

[2] Chairman of Committee on Pumping Station Betterments; Mechanical Engineer, St. Louis, Mo.

THE LIFE OF A BELT CONVEYOR AND COST PER TON OF COAL HANDLED, ST. LOUIS WATER DEPARTMENT[1]

By Leonard A. Day[2]

When the boiler room at Bissell's Point Station of the St. Louis Water Works was reconstructed some eight years ago, a belt conveyor was installed to convey and elevate the coal. It is 215 feet between centers and elevates the coal 53 feet, starting at a track hopper outside the building and delivering the coal to a group of four bunkers in the boiler room. An average of seventy tons of coal per day have been handled for the past eight years, 204,400 tons in all, before the belt was replaced. It is made of 5-ply, 28 oz. duck, with $\frac{1}{8}$-inch rubber cover on the wearing side. It cost $831.60 at $1.89 per foot. This gives a belt cost of 0.4 cent per ton to move the coal through the distance and to the elevation stated.

[1] Prepared under the auspices of Committee No. 7, on Pumping Station Betterments.

[2] Chairman of Committee on Pumping Station Betterments; Mechanical Engineer, St. Louis, Mo.

THE NEW WATER SUPPLY QUALITY STANDARD TENTATIVELY PROPOSED BY THE UNITED STATES PUBLIC HEALTH SERVICE

In May, 1922, the Surgeon General of the United States Public Health Service appointed a series of committees to consider the problem of developing a satisfactory standard of measurement of water supply quality. The work was divided between three primary committees, one dealing with bacterial, another with chemical and physical, and a third with sanitary survey problems. The recommendations of these three committees are to be submitted to an Appraisals Committee for final review and adjustment. As sections of the report are completed, it is the purpose of the Appraisals Committee to submit them for discussion and criticism to various interested national organizations.

The report of the Bacteriological Subcommittee has been completed and has been reviewed and adjusted by the Appraisals Committee. It represents the first section of the series and is to be used as an integral part of a standard, of which the sanitary survey and the physical and chemical requirements provide the remaining elements. The reports on these latter requirements are already under way.

The Standardization Council of this Association is desirous of presenting to the Appraisals Committee of the United States Public Health Service a comprehensive view of the proposals so far completed by the Committee. For this reason, the proposed standard for bacterial content, the first section of the whole report, is here reproduced, so as to make it available to our members for review and criticism. The Standardization Council requests each member of the Association to forward to the Secretary of the Council, Mr. Malcolm Pirnie, 25 West 43rd Street, New York City, such tabulations of water supply bacterial contents as they may have available for past years and such discussions of the proposals herein reproduced as may be pertinent to the subject in hand. Immediate response to this request on the part of a majority of interested members is essential if the Council is to extend its coöperation to the United States Public Health Service and to make articulate the views and opinions of this Association to the Appraisals Committee.

Following the report here below reproduced are presented the views of members of the Association so far reviewed by the Council. They are given here as the first contribution to the discussion of an important question.

REPORT OF SUB-COMMITTEE ON BACTERIOLOGICAL STANDARDS AS AMENDED BY SUB-COMMITTEE ON APPRAISAL

Part 1. The bacteriological standard proposed

A. Definitions:

1. *Index Organism:* B. coli group, as determined in accordance with Standard Methods of the American Public Health Association, current edition, by inoculation in lactose broth fermentation-tube, transplant to endo or eosin-methylene-blue agar plate and inoculation in secondary lactose broth fermentation-tube.

2. *Standard Portion of Water:* Ten cubic centimeters.

3. *Standard Sample of Water:* Five standard portions of ten cubic centimeters each.

B. Limits of permissible density of bacillus coli-group:

Not more than 10 per cent of all the ten cubic centimeter standard *portions* examined shall show the presence of organisms of the bacillus coli group.

(a) When the number of standard *samples* collected is over twenty, not more than 5 per cent of all the *samples* shall show three or more *positive* tests out of the five 10 cc. portions comprised in any single sample.

(b) When the number of standard samples collected is less than twenty, not more than *one sample* shall show three or more positive tests out of the five 10 cc. portions.

Part 2. Discussion of the proposed bacteriological standard

The establishment of a bacteriological standard for drinking water requires an agreement upon the basic unit or units which are to compose the standard and upon the methods by which such units are to be evaluated. In other words, the Committee have taken for their task the definition of a basic unit and the promulgation of limiting values for this unit.

In the bacteriological examination of water supplies, several bacterial indices are commonly used to detect and measure pollution.

Of these, only the standard test for bacteria of the B. coli group is included in the present standard, as it represents the nearest approach to an index of fecal contamination. The standard would be unnecessarily complicated by the inclusion of either the 37°C. or 20°C. total bacterial count since, for judging the safety of a potable water, neither of these counts adds sufficiently important information, which is not already available from the bacillus coli test, to warrant its addition. The absence of any general and well-defined quantitative correlation between the bacillus coli group and other bacterial enumerations gives added support to the desirability of restricting the number of units of measurement in the standard to only one.

It is undoubtedly true that the 37°C. and 20°C. bacterial counts are of great value and accuracy in routine water analysis for purposes of diagnostic aid and control of purification processes; and the Committee wish to record their belief that it would be unwise and unsafe to discard the above indices of water pollution as an auxiliary to B. coli tests. Simplification of the standard, however, demands the restriction set forth herein to the colon group as the basic unit in the proposed standard.

In a similar manner, it has been agreed that, in the present state of knowledge, sufficiently reliable or complete evidence is not yet available upon which to recommend, in the standard, the differentiation and isolation of various forms of the B. coli group, in any greater detail than has been indicated in the definition of the index organism. (See A-1)

The Committee have felt that, in view of the existence of the American Public Health Association Standard Methods of Water Analysis, their own activities should be restricted to the promulgation of limiting values of the index organism, rather than to the initiation and re-statement of standard methods of evaluating the unit adopted. For this reason, they recommend that the standard technique, media, allowable period of delay between sample collection and examination and associated machinery of unit-evaluation be fixed as of the methods set forth in the Standards Methods of Water Analysis, A. P. H. A. Current Edition.

The selection, as a standard sample, of five 10 cc. portions of water has its origin in the fact that such a series of portions makes available a yardstick, for our present purpose, whose subdivisions on a scale of pollution are finer than would be obtainable by the use of the more common geometric series of 100, 10, 1, etc., cubic centimeters. In

the geometric series we have the use of a yardstick of greater range of pollution, but of much coarser subdivisions. Since we are concerned in our present problem with a limited pollution, the choice of a shorter yardstick with finer subdivisions is deemed wise. The mathematical evidence supporting the selection of the standard sample of five 10 cc. portions, in place of the geometric series, is set forth in detail in the appendix[1] attached to this report.

The formulation of the *standard sample* does not eliminate in any study the necessity for testing small amounts of water, such as 1, 0.1, 0.01, etc. cc. for the determination of greater pollutions. It should be emphasized that the range of pollution covered by five 10 cc. portions of water is restricted to that in the vicinity of a water bacteriologically safe for drinking purposes.

The frequency of collection of standard samples has been given considerable thought. The statistical advantages of frequent sample collections must be balanced against the practical difficulties. With these difficulties in mind, and with due regard to the inadequacy of only one or two samples a year, it is recommended that samples of each potable water shall be collected in each calendar year in accordance with the requirements of origin and method of treatment of the water.

As soon as more than one sample of a water supply is at hand for interpretation, there arises at once the problem of determining permissible variations in the density of organisms found in individual samples. Whether we choose to recognize the fact or not, variations from a most frequent value of B. coli density occur in waters. These deviations are great or small in amount and in frequency depending upon the history of the water and upon the chances involved in the technique of collection and examination. Definite recognition of these variations is essential in any bacteriological standard, for a mere statement or average or most frequent B. coli density gives no criterion of the allowable irregularities or deviations which we know are continually arising. A recognition of these deviations does not imply the lowering of the quality standard, but simply makes apparent the necessity of placing a limiting value upon irregularity of results.

[1] The appendix is not reproduced here because of delay in collecting the material here presented and the difficulty of setting in type the complex mathematical symbols involved in the discussion.

In the present standard proposed by the Committee, therefore, two limiting values are suggested. One establishes a limit for most frequent density of bacilli and the other gives the maximum deviations from the most frequent value which are considered permissible for current practice. The standard tacitly recognizes that such results as one, or two, or three positives out of five 10 cc. portions may and do occur in the best regulated water supplies. The problem confronting the Committe, therefore, is what percentage of excessively high results in a satisfactory water supply may be attributed to chance and what to a definite deterioration of quality which may have dangerous implications?

The first criterion established by the Committee, namely, that "not more than 10 per cent of all the ten cubic centimeter standard portions examined shall show the presence of organisms of the B. coli group," implies a most probable density of one B. coli per 100 cc. in a water supply, when about 100 portions are tested. In other words, if a water supply is maintained consistently of a bacterial quality equivalent to a concentration of B. coli of one per 100 cc., then 10 per cent of all 10 cc. portions thereof examined will be found positive.

On the other hand, chance occurrences have demonstrated and the theory of random sampling would predict that, in this same water of actual constant B. coli density, *some* portions of water tested would contain 3, 5, or 10 B. coli per 100 cc. or 2, 3, etc. out of five portions of 10 cc. might be found positive at some time or other. Such variations from constant density are due to errors of simple sampling, which may be evaluated and for which allowance should be made in the standard. This is particularly essential, since the standard, in addition to limiting the total percentage of positive portions, must limit also the frequency of *high* results in any single sample, in order to avoid dangerous supplies.

A limiting value for this frequency of high results may be gleaned from a study of the figures which the theory of random sampling would indicate for a water of constant density of B. coli of one per 100 cc. or of ten per cent positive in 10 cc. portions. The expected frequency of the results 1, 2, 3, 4 and 5 positive out of five 10 cc. portions, with such a water as above, due to errors of sampling, has been calculated in the appendix.

It is found there that the result 3 out of 5 positives in 10 cc. would occur in only about one per cent of all the samples tested, due only

to chance fluctuations in sampling. The Committee have felt, therefore, that, by placing the second criterion of the proposed standard as "not more than 5 per cent of all the samples shall show three or more positive portions out of five 10 cc. in any single sample," sufficient concession is made to the possibilities of chance occurrences to permit of practicable application to current water supplies.

The results, 1 or 2 out of five 10 cc. portions, were not chosen as the bases for variation limits, since their chance occurrences, as demonstrated in the appendix, are so great, with the desired B. coli density, as to make the limits inadequate.

By setting a limiting value to variations from most frequent density of bacteria, the Committee recognizes a "state of irregularity" in waters but fixes the permissible fluctuation within a range above that of chance and below that considered dangerous.

These criteria are indicated numerically, for four cases, in the tabulation below:

TAP WATER	NUMBER STANDARD SAMPLES TESTED	NUMBER OF PORTIONS	NUMBER SAMPLES SHOWING POSITIVE TESTS IN					PER CENT PORTIONS POSITIVE	CONFORMS TO STANDARD CLAUSE (a)	PER CENT SAMPLES WITH 3 OR MORE POSITIVE OUT OF FIVE 10 cc.	CONFORMS TO STANDARD CLAUSE (b)
			0/5	1/5	2/5	3/5	4/5				
A	20	100	15	3	2			7.0	Yes	0	Yes
B	20	100	15	2	1	1	1	11.0	No	10	No
C	20	100	17	1	1	1		6.0	Yes	1 sample	Yes
D	100	500	75	20	3	1	1	6.6	Yes	2	Yes
Standard								10.0		5	

These statistical implications are discussed at greater length in the appendix.

In the formulation of such a standard as is here proposed, the Committee naturally should be guided by the probability of having the requirements met by existing water supplies under economical and practicable operation. In order to test out this aspect of the problem, data have been listed in table 1, giving recent tap water analyses of American cities selected at random. The figures in table 1, though by no means as complete as is desirable, would appear to indicate that the proposed standard would not place any undue burden upon water works, which is not overbalanced by the desirable results obtainable.

TABLE 1

CITY	YEAR	NUMBER SAMPLES OF FIVE 10 CC. EACH	PER CENT PORTIONS POSITIVE IN 10 CC.	PER CENT SAMPLES SHOWING $\frac{3}{5}$ OR MORE POSITIVE IN 10 CC.
Standard Requirements			*10 or less*	*5 or less*
Atlanta, Ga.	1919	1070	22.50	
	1920	1095	1.27	
	1921	1095	0.90	
Jan. 1–July 1	1922	543	0.90	
Baltimore, Md.	1922	221	1.7	2.2
Cincinnati, Ohio	1919	365	3.0	
	1920	366	5.0	
	1921	365	1.4	
Jan. 1–Oct. 1	1922	273	3.6	
Cumberland, Md.	1922	81	13.0	10.0
Detroit, Mich.	1919	918	0.8	0.0
	1920	932	1.0	0.0
	1921	918	0.5	0.0
Jan. 1–Oct. 1.	1922	690	0.7	0.0
Hyattsville, Md.	1922	52	5.4	3.8
Kansas City, Kans.	1919	356	0.7	0.3
	1920	364	0.9	0.3
	1921	362	1.8	0.8
Jan. 1–Oct. 1	1922	271	6.1	6.0
Luke, Md.	1922	107	3.4	1.8
Milwaukee, Wis.	1919	357	27.7	20.0
	1920	807	27.7	
	1921	801	23.7	
Jan. 1–Oct. 23	1922	649	25.9	
Minneapolis, Minn.	1920	665	1.2	0.5
	1921	725	0.4	0.0
Jan. 1–July 1.	1922	349	0.07	0.0
New Orleans, La.	1919	295	0.8	0.0
	1920	288	1.3	0.0
	1921	300	1.0	0.3
Jan. 1–July 1	1922	146	0.9	0.0

TABLE 1—*Continued*

CITY	YEAR	NUMBER SAMPLES OF FIVE 10 CC. EACH	PER CENT PORTIONS POSITIVE IN 10 CC.	PER CENT SAMPLES SHOWING $\frac{3}{5}$ OR MORE POSITIVE IN 10 CC.
Standard Requirements			*10 or less*	*5 or less*
*New York, N. Y.**				
A. Croton Supply	1919	313	6.0	
	1920	314	10.0	
	1921	311	3.0	
Jan. 1–June 10	1922	137	0.7	
B. Catskill Sup.	1919	365	17.0	
	1920	362	22.0	
	1921	364	28.0	
Jan. 1–June 10	1922	164	0.6	
Norfolk, Va.	1919	308	13.0	
	1920	318	19.0	
	1921	303	1.0	
Jan. 1–June 1	1922	132	10.0	
June 1–Oct. 1	1922	102	12.1	5.0
Providence, R. I.	1919	299	15.4	
	1920	269	15.3	
	1921	300	13.7	
Jan. 1–Nov. 1	1922	249	31.7	
San Francisco, Cal.	1919	158	28.1	32.0
	1920	188	26.5	30.0
	1921	187	5.6	5.0
Jan. 1–Nov. 1	1922	133	3.1	2.3
Seattle, Wash.	1919	132	1.7	0.0
	1920	137	11.4	10.0
	1921	158	5.0	4.0
Jan. 1–Oct. 23.	1922	109	11.4	8.0
Terre Haute, Ind.	1920	366	2.5	0.8
(filtered only)	1921	365	2.8	0.6
Jan. I–July 1	1922	181	4.5	1.1
Washington, D. C.	1919	880	1.9	
	1920	829	4.8	
	1921	831	3.1	
Jan. 1–Oct. 1	1922	614	6.5	
Wilmington, Del.	1918–19	1681	17.1	
	1919–20	1810	8.7	
	1920–21	1820	2.7	
Wilmington, N. C.	1920	2532	3.2	
	1921	1405	5.3	
Jan. 1–Oct. 1	1922	951	3.3	

* Presumptive tests in brilliant green bile.

DISCUSSION FROM VARIOUS SOURCES OF THE APPLICATION TO LOCAL CONDITIONS OF THE PROPOSED UNITED STATES PUBLIC HEALTH STANDARD FOR WATER USED ON INTER-STATE CARRIERS

A letter was sent to officials in many cities, asking that a study of the results of examinations of their supplies be made to determine whether or not these results would meet the proposed bacteriological standard. The following are excerpts from letters received in reply:

Cleveland, O., May 15, 1923.

I know that the old U.S.P.H. standard could not be met by the average filter plant and this one is more rigid, and needlessly so.

—*M. F. Stein.*

Iowa State College, Ames, Iowa.
May 12, 1923.

It is my personal opinion, however, that, for surface supplies which are being purified, the screws are being applied rather tightly. If this suggested standard is to be applied to the water as it is found on the interstate common carriers, I believe they are on the right track in eliminating the bacterial count, and the colon specifications are also desirable. If, however, this standard is to be shifted on to municipal supplies, as was done with the previous standard for interstate common carriers, I cannot accept the opinion of the committee without considerable qualification.

—*Max Levine.*

Kansas City, Mo., May 2, 1923.

It is my personal belief that it would be pretty hard for most of the filtration plants not having very thoroughly organized chemical and bacteriological supervision to meet the requirements.

—*N. T. Veatch, Jr.*

Provincial Bureau of Health, Montreal.
May 14, 1923.

Upon glancing over the report of Mr. Freeman and the adjoined report of the U.S.P.H.S. Committee, I was rather surprised to find that the Treasury Standard had been made more rigid. I am wondering whether the small community, forced to use surface water which may contain B. Coli of doubtful significance, will not find the Standard pretty difficult.

—*M. H. McCrady.*

May 10, 1923.

It is my opinion the proposed new B. coli standard is too high for treated surface waters. It is, of course, desirable to provide a high mark to strive for. Why not establish two standards, one a minimum, below which no decent water may drop, and a maximum standard, which if reached would entitle

the operator to a Fellowship in the Am. Pub. Health Association. Set the maximum standard at say, not more than 0.01% of 10 cc. samples showing B. coli, and it may escape revision for another ten years. It furnishes a convenient weapon for anyone who may wish to destroy public confidence in private or public supply. Before the standard is raised, there should be ample justification in the form of data proving conclusively that the present requirements do not insure safe water.

—*Weston Gavett.*

Department of Public Health, Boston, Mass.
May 8, 1923.

I can say, however, in regard to the principal filtered water supply of the State, that of Lawrence, that the effluent from the filters even after chlorination, does not satisfy the present requirement of the United States Public Health Service and neither would it satisfy the proposed requirements of the committee; yet this supply is used year after year and only on two or three occasions in the last thirty years have we felt even reasonably certain that any typhoid in the city was due to its use and on these occasions we have known that either the filter had been poorly operated temporarily or the chlorine plant out of order.

Your proposed requirement (A) seems to me fairly reasonable although it would not be met by quite a number of our surface supplies which as you know are stored waters from ponds and reservoirs, used unfiltered, these waters judging from all typhoid records being safe, however.

—*H. W. Clark.*

State Board of Health, Lawrence, Kansas.
May 5, 1923.

My reason for considering the purposes for which this standard is to be used is that I think there are certain conditions where your proposed standard would be very good and other cases where it would be too severe. The majority of plants are able to meet the present standards of the U. S. Public Health Service, but I am a little doubtful as to whether they could meet the proposed standards.

—*Albert H. Jewell.*
Chief Engineer.

Troy, N. Y., May 7, 1923.

I fear that I do not take very kindly to the standards proposed. It is so easy to be led astray by a "standard" that I anchor my faith very largely upon the "sanitary survey."

The view that I have held for years I find expressed in the following extract from a recent number of the American Journal of Public Health.

"We believe that the differences between soil and fecal strains is of little practical significance to the sanitarian, and will not help him in judging as to the proximity of the source of contamination.

"Certainly a ground water to be safe should be free from B. coli just the same as it should be free from great numbers of any soil organisms. But

without doubt, unwarranted condemnation of farm water supplies are being made every day based on the presence of lactose fermenting bacteria.

"This then is a plea for more efficient, sanitary and biological surveys before judging the potability of a water supply, or the efficiency of any method of purification."

—*W. P. Mason.*

Davenport Water Co., Davenport, Iowa.

I do not understand that part of the proposed requirements stating "when the number of standard samples collected is over 50." That may mean 50 samples in a year or in a less period of time.

—*C. R. Henderson.*

City of Albany, N. Y., Bureau of Water.

A satisfactory drinking water embodies other characteristics than coli content alone. Certainly a consumer would not consider a water with a color and hardness of 100 as being satisfactory in the long run.

It especially seems to me that the standard sample consisting of five 10 cc. portions is not generally applicable to the conditions attained at all treatment plants, and I certainly would be concerned if this clause were adopted without modification.

Many plants are operated under such adverse conditions as to make the disinfection process the prime essential. Such plants must make many analyses extending throughout the 24 hours, if the disinfectant is to be successfully applied. It would be a hardship for such plants to make coli determinations on five 10 cc. portions of all standard samples collected. It is in just such cases as these that the needs of the average water works differs from that of the common carrier. Again, let me assure you of my agreement with the intent of the proposed standard. It is simple and concise and I believe with slight modifications that it may be made applicable to general water works conditions.

YEAR	TOTAL NUMBER 10 CC. COLI TESTS MADE	NUMBER OF 10 CC. TESTS THAT WERE POSITIVE	PER CENT OF 10 CC. TESTS POSITIVE	TYPHOID DEATH RATE PER 100,000
1910	470	39	8.3	18.9
1911	881	86	9.8	16.7
1912	604	35	5.8	17.4
1913	627	62	9.9	26.6
1914	647	80	12.3	16.0
1915	615	37	6.0	13.9
1916	624	19	3.0	6.4
1917	847	127	15.0	8.3
1918	803	39	4.9	10.1
1919	816	9	1.1	10.0
1920	868	57	6.6	4.5
1921	864	18	2.1	5.3
1922	843	66	7.8	1.7

You will note from the above that this plant fulfilled the requirements of the first proposed standard in all years except two. You may recollect that since 1914 the Albany Plant has practically depended entirely on chlorination to produce a potable water so that, if Albany can meet the proposed standard, it would seem that almost any other plant could do likewise.

—*George E. Willcomb.*

City of Baltimore, Md., Water Dept.
May 9, 1923.

I am attaching herewith a tabulation showing the number of B. coli tests made each month for the last four years. In only one month, that of November 1921, did we have over three positive tests. You can see that we would have no particular trouble in meeting the government requirements with our water.

Determination of B. coli—final tests by isolation; Baltimore City Water Department Filtration Division

MONTH	NUMBER DAYS	NUMBER DAYS SHOWING ⅔ POSITIVE	MONTH	NUMBER DAYS	NUMBER DAYS SHOWING ⅔ POSITIVE
1919			1921		
January	26	0	January	25	0
February	23	0	February	23	0
March	26	0	March	28	0
April	24	0	April	26	0
May	25	0	May	25	0
June	25	0	June	26	0
July	26	0	July	28	0
August	26	0	August	27	0
September	25	0	September	24	0
October	27	0	October	26	0
November	24	0	November	24	1
December	26	0	December	24	0
1920			1922		
January	27	0	January	22	0
February	24	0	February	24	0
March	27	0	March	24	0
April	25	0	April	24	0
May	25	0	May	26	0
June	26	0	June	24	0
July	26	0	July	25	0
August	26	0	August	27	0
September	24	0	September	25	0
October	25	0	October	26	0
November	23	0	November	23	0
December	26	0	December	25	0

J. R. Baylis, and J. W. Armstrong.

Boston, Mass., May 18, 1923.

I wish to state that the data relative to the B. coli content of the Boston Water Supply indicate that the supply could not be certified under the new standard. The tests for B. coli are, however, presumptive only, while the typhoid death rate in Boston is very low. I have the personal feeling that the supply should be chlorinated, although this opinion is based upon general principles rather than upon the results for B. coli.

—*E. S. Chase.*

Mesabi Iron Co., Babbitt, Minn.
May 3, 1923.

The water works system at Babbitt has just been in operation a year. While the raw water is taken from a highly polluted swamp, it has been successfully treated for domestic purposes. There are times when it is impossible to remove the last traces of the swamp taste, but out of 195 samples taken, only two showed organisms of the B. Coli group.

It might be of interest to know that to maintain 0.1 to 0.2 p.p.m. of residual chlorine it was necessary to add 2.4 p.p.m. to the filtered water. 5.6 grains of alum per gallon were necessary to remove the high color.

—*James R. Mitten.*

City of Cleveland, Division of Water.
May 26, 1923.

In general I agree with Dr. E. O. Jordan to the extent that he expresses a doubt that typhoid fever mortality statistics would be found correlated with the B. coli content of the water supplies listed in the report. I believe, also, that if a comparison of the typhoid statistics and B. coli content of the drinking water supplies of a much larger number of towns and cities were made, that we would find comparatively few cases that would be cause for alarm.

I also agree with Mr. H. E. Jordan, wherein he questions the necessity for making the standards so rigid, considering the available evidence derived from the apparent sanitary quality of those water supplies which do not quite meet the standard. While agreeing with the Committee that any standards adopted must necessarily be largely arbitrary, it seems to me that too little weight is given to the fact that waters that do not quite meet the standards are, nevertheless, regarded as safe and healthful drinking waters, and that evidence is lacking that would condemn such supplies.

I believe the Committee are right in selecting the B. coli content as the best index of pollution, although it may not be the only one available. It undoubtedly has become the criterion by which the purity of drinking waters are judged, although the extent to which it is relied upon as an index of pollution is not, in my opinion, justified. The Committee's decision to make the standard method of testing such that the variations in concentration of the B. coli organism are emphasized is probably sound, although it will make much more laboratory work where several samples a day are collected for examination, especially in the large water purification plants.

It is not clear to the writer why the Committee felt justified in lowering the B. coli content, namely, to one per 100 cc., considering that formerly an

index of two per 100 cc. was supposed to represent a perfectly safe water. What new evidence has been found that would indicate that two B. coli per 100 cc. were any more likely to have disease producing organisms associated with them than one B. coli per 100 cc.?

While the weakness of the technique of differentiating the B. coli group into those of fecal and non-fecal origin is recognized, it seems to the writer that sufficient evidence may be obtained by present methods of differentiation to warrant less weight being given to the B. coli test as a whole, since deductions made as to quality by the inclusion of both types in the standard may and probably does work a hardship on certain classes of water. It is a factor of safety that I wonder whether the Committee took into consideration.

The psychological effect of establishing a needlessly rigid standard is to create the belief that it represents the upper limit of safety, and that any greater concentration of B. coli must indicate a water that is unsafe to drink. If the standard as proposed truly represents the border line between a safe and an unsafe water, there would be no dispute as to how to classify a water which is either above or below the limits set. However, there would be a real doubt in my mind how to grade a water for drinking purposes if the proposed limits are adopted.

Granting that factors of safety are desirable and necessary, and that we must lean toward the safe side rather than the unsafe side, it seems to me that the standards are more rigid than is "consistent with economy in the best engineering practice of the present day." While these conclusions are largely matters of opinion and not susceptible of definite proof, it would appear that certain members of the Committee objected to the original provisional standard as too rigid. I presume that those permitted to criticise the report have the same privilege of believing that the standards are still too severe for many large water supplies to be able continuously to meet them.

—*J. W. Ellms.*

Cincinnati Water Works, California, Ohio.

1. We examine but one sample per day for B. coli, and plate only one 10 cc. portion for this purpose. From Jan. 1, 1919 to May 1, 1923, we therefore examined 1580 10 cc. portions of our final output, collected at a point about 4 to 6 hours later than time when chlorine was applied. Chlorine added amounts to 1.3 lbs. per m.g. (0.15 p.p.m.), while residual chlorine at the sampling point averages about 0.01 to 0.04 p.p.m. during the winter, and only from zero to 0.01 or 0.02 p.p.m. in summer.

These 1580 samples have yielded 76 positives in 10 cc., i.e., 4.8 per cent of the total number of 10 cc. portions, whereas the revised standard permits 10 per cent of positives.

2. Roughly, a positive is obtained say every 15 or 20 days, and never has there been a positive on consecutive days. Therefore, it seems improbable that as high as 5% of any of the samples contained B. coli in such quantities that three out of five 10 cc. portions would have been positive.

3. The B. coli index per 100 cc. (confirmed) of our final output has shown the following averages:

1918	2.0
1919	0.6
1920	1.1
1921	0.4
1922	0.7

From this it appears that since 1919 our product would pass the revised standard nicely.

We therefore feel that we easily can meet the requirements, but only through the use of chlorine. Our plain unsterilized effluent has met the old 2 B. coli per 100 cc. standard, as a monthly average, for only 28% of the months from Jan. 1, 1918, to Jan. 1, 1922.

The difference between presumptive and confirmed positives at this plant is very slight in comparison with the published results of other plants. The failure to confirm a large proportion of the presumptive positives in chlorinated water, which seems to be the case at so many plants, has never occurred to any pronounced degree at Cincinnati. We have studied our data for the last 5 years quite intensively, and several papers dealing with these studies will eventually be published by the State Dept. of Health in connection with the proceedings of our last conference on water purification.

Thus, the percentage of positive presumptives which have been confirmed during 1919–1922 is as follows:

	per cent
River Water	88.6
Settled Water	88.0
Influent Water	89.8
Filtered Water	89.9
Chlorinated Water	83.6

There is therefore only a slight falling off in confirmations in chlorinated water.

It is of course possible that the examination of five 10 cc. portions of a sample would give somewhat different results than we have obtained by examining only one 10 cc. portion. We also examine 100 cc. portions by enrichment with phenol-lactose broth followed by planting into standard lactose broth tubes. In our earlier letter we mentioned that only 76 samples (4.8%) of 1580 samples examined from Jan. 1, 1919, to May 1923, were positive. This may be amplified as follows:

76 samples (4.8%) positive in 10 cc.
475 samples (30.1%) positive in 100 cc., negative in 10 cc.
1029 samples (65.1%) negative in 100 cc.

1580

Therefore on the basis of only 4.8% positives in the total number of 10 cc. samples we could meet the proposed standard.

I assumed that the proposed new standard was equivalent to 1 B. coli per 100 cc. If it figures out to be 0.3 per 100 cc., Cincinnati water at least will never be of standard purity. It might approach the 0.3 B. coli standard if we carried residual chlorine to the ultimate tap, but personally I do not

consider appreciable quantities of residual chlorine at the tap to be necessary, or even advisable.

Since Jan. 1, 1918, we have used chlorine continuously and the annual B. coli index of the final output of the plant has ranged from 0.4 to 2.0. Typhoid cases have varied from 56 to 84, and deaths from 11 to 17. Approximately 65–80% of these cases have been traced by the City Health Dept. to definite sources other than the city water.

It is our opinion that our water is perfectly satisfactory as demonstrated by the vital statistics. If we were able to bring it down to 0.3 B. coli per 100 cc., we feel certain that there would be no betterment in typhoid cases. The 0.3 B. coli water would be purer than the present supply only on paper and not actually better.

Therefore, I am opposed to any standard which will cast suspicion upon a water which has demonstrated its purity by vital statistics. It is my opinion that a chlorinated water as an average ought not to exceed 2 B. coli to any great extent, but the standard certainly ought not to be under 1 B. coli, and I am in favor of letting it stand as at present, 2 B. coli per 100 cc.

—*Clarence Bahlman.*

City of Cleveland, Division of Water.
May 2, 1923.

I have no results compiled according to the United States Public Health Standards, but from the following tables you will observe the results obtained on the Cleveland Water by the American Public Health Standard for the past five years.

B. coli index per cubic centimeter

	1918	1919	1920	1921	1922
Lake water	0.840	1.666	1.597	3.079	1.307
Settling Basin effluent	0.205	0.277	0.528	1.792	0.384
Filtered water	0.066	0.087	0.110	0.439	0.086
Disinfected filtered water	0.017	0.009	0.021	0.019	0.001

—*W. C. Lawrence.*

City of Dallas, Texas.
May 17, 1923.

I have looked up our bacterial records for the years 1919, 1920, and 1921 and find that during these years we have examined 776 ten cubic centimeter samples of the water after final treatment and that 83 showed organisms of the Coli group (those samples were first sowed in lactose broth). Any of those that showed even traces of gas in 48 hours, were transferred to either litmus or purple agar, and incubated for 24 hours. Two or three of the colonies whether typical or atypical were fished out and again transferred to lactose broth, any of these showing gas were called B. coli. Sometimes microscopic examinations were made, most of the time, however, none were made. You can, therefore, see that our results are on the conservative side

of the fence. Unquestionably a great number of those samples upon further examination would have shown the absence of B. coli.

However, considering that all of those were of the B. coli group. The average of the three years is 10.7%.

During the same period we examined 410 ten cubic centimeter samples of city tap waters, and 51 of these showed the presence of the B. coli group, (using the same methods as above described). This makes an average of 12.4%.

I am of the opinion that most of the plants could pass the requirement that not more than 10% of all the ten cubic centimeter portions examined shall show the presence of organisms of the B. coli group. If our plant had sand filters instead of coal, we would have had no trouble in meeting the requirement. In the future we hope to go below this, as we have just completed a new modern rapid sand filter plant. However, even with the old plant we have been able to reduce our typhoid death rate from an average of 48 per 100,000 to 5 per 100,000 in 1922, and a few of those that died were known to have contracted the disease outside of the city.

—*H. Rosenthal.*

East St. Louis & Interurban Water Co., Illinois.
May 23, 1923.

After having investigated our results for a number of years we find that generally we can meet the proposed standard.

—*E. E. Wolfe, Chemist.*

Commissioners of Water Works, Erie, Pa.
May 8, 1923.

YEAR	FILTERED WATER SAMPLES EXAMINED	SAMPLES SHOWING B. COLI PRESENT
1914	717	0
1915	573	0
1916	595	1
1917	579	1
1918	680	2
1919	607	0
1920	609	0
1921	610	0
1922	602	0

The above results do not represent 10 cc. examinations as we have always followed the general practice of making five 1 cc .sowings from each sample and reporting B. coli on any positive reaction.

—*J. S. Dunwoody.*

Flint City Water Works, Flint, Michigan.
May 2, 1923.

We can say that we meet during the greater part of the year the present United States Public Health Service Standards for a drinking water. How-

ever, during times of high color in the raw water, we have not been able to meet the present, i.e., the old standards from the standpoint of presumptive tests for B. Coli. "Only one out of five 10 cc. tubes can produce fermentation." The greater part of the time, however, we are meeting the new suggestions for a standard as set forth by the present committee.

Under varying conditions of the river water, however, we have been adding to the filter water chlorine as high as 0.7 p.p.m. With high color conditions, we do get a very resistent bacterium that seems to fall into the Aerogenes Class generally, but sometimes will turn out a negative Voges-Proskauer.

It would seem to me from the local practical conditions of the river water, that the old U.S.P.H. Standards are plenty high enough to aim at. We have done better than this standard as already mentioned above, but we cannot continually meet a still more rigid standard, if the new standard is to apply to municipal supply, without getting chlorine into the taste range, which is of course, a mighty important condition to avoid.

—*R. S. Buzzell.*

City of Grand Rapids, Mich.
May 16, 1923.

I think you will agree with us when you look over our results that your proposed standard seems a bit stringent. While we have had plenty of bacterial problems, yet we feel that in view of our typhoid records for the past five years our filtered water has been in fair condition.

Grand Rapids

1922

MONTH	DAYS TESTED	NUMBER OF TESTS	NUMBER DAYS POSITIVE B. COLI IN FIVE 10 CC. VOL.					NUMBER TESTS POSITIVE	PER CENT TESTS POSITIVE
			1/5	2/5	3/5	4/5	5/5		
January	31	155	3	1	0	3	0	17	*11
February	28	140	3	4	0	1	3	30	*21
March	31	155	1	0	2	0	0	6	4
April	30	150	0	0	0	0	0	0	0
May	31	155	3	1	3	0	0	14	9
June	30	150	3	1	0	0	1	10	7
July	31	155	0	3	0	1	0	10	6
August	31	155	5	5	1	0	0	18	*12
September	30	150	2	1	1	0	0	7	5
October	31	155	0	1	0	0	0	2	1
November	30	150	3	2	0	0	0	7	5
December	31	155	3	1	1	1	3	27	#17
	365								

For 66⅔ per cent of time during 1922 we were able to meet the proposed standard (1).

With respect to (a) part of proposed standard, its application to above data would be made for the year as not more than 31 samples are collected per month. 365 samples collected per year.

21 of those samples or 5.7 per cent of all the samples showed three or more positive portions out of five 10 cc. in every single sample.

1921

Month	Days tested	Number of tests	Number days positive B. coli in five 10 cc. vol.					Number tests positive	Per cent tests positive
			1/5	2/5	3/5	4/5	5/5		
January	31	155	5	1	0	0	0	7	5
February	28	140	0	0	1	0	0	3	2
March	31	155	2	1	0	0	0	4	3
April	30	150	5	1	2	0	0	13	9
May	31	155	5	2	1	0	0	12	8
June	30	150	6	1	3	0	0	17	11
July	31	155	5	0	0	4	0	21	14
August	31	155	0	0	1	1	0	7	5
September	30	150	5	0	0	0	0	5	3
October	31	155	3	0	1	1	0	10	6
November	30	150	0	1	2	1	0	12	8
December	31	155	0	0	1	0	0	3	2

For 2 months of year results did not meet proposed standard.

83⅓ per cent of time during 1921 we were able to meet the proposed standard.

365 samples collected during the year.

19 of those samples or 5.2 per cent of all the samples showed three or more positive portions out of five 10 cc. in every single sample.

1920

January	31	155	4	3	0	0	0	10	7
February	29	145	1	2	1	0	0	6	4
March	31	155	1	3	1	0	0	10	7
April	30	150	0	1	1	0	0	5	3
May	31	155	5	1	1	0	0	10	7
June	30	150	8	2	4	0	1	27	18
July	31	155	4	1	0	1	0	10	7
August	31	155	2	2	0	0	0	6	4
September	30	150	1	0	0	1	0	5	3
October	31	155	2	0	0	0	0	2	1
November	30	150	0	0	0	0	0	0	0
December	31	155	4	1	0	0	0	6	4

For 1 month of year results did not meet proposed standard.

91.6 per cent of time during 1920 we were able to meet the proposed standard.

365 samples collected during the year.

11 of those samples or 3.0 per cent of all the samples showed three or more positive portions out of five 10 cc. in every single sample.

1919

MONTH	DAYS TESTED	NUMBER OF TESTS	NUMBER DAYS POSITIVE B. COLI IN FIVE 10 CC. VOL.					NUMBER TESTS POSITIVE	PER CENT TESTS POSITIVE
			$\frac{1}{5}$	$\frac{2}{5}$	$\frac{3}{5}$	$\frac{4}{5}$	$\frac{5}{5}$		
January	31	155	1	2	0	2	0	13	8
February	28	140	2	7	0	0	0	16	11
March	31	155	0	0	0	0	0	0	0
April	30	150	0	0	0	0	0	0	0
May	31	155	0	0	0	0	0	0	0
June	30	150	0	0	3	0	0	9	6
July	31	155	1	0	0	0	0	1	1
August	31	155	0	0	0	0	0	0	0
September	30	150	1	0	0	0	0	1	1
October	31	155	1	1	0	0	0	3	2
November	30	150	2	1	0	0	0	4	3
December	31	155	1	2	0	0	0	5	3

For 1 month of year results did not meet proposed standard.

91.6 per cent of time during 1919 we were able to meet the proposed standard.

365 samples collected during the year.

5 of those samples or 1.3 per cent of all the samples showed three or more positive portions out of five 10 cc. in every single sample.

1918

January	31	155	5	4	2	1	2	33	21
February	28	140	0	1	1	3	1	22	16
March	31	155	3	0	0	0	0	3	2
April	30	150	0	0	0	0	0	0	0
May	31	155	2	1	0	0	0	4	3
June	30	150	4	0	0	0	0	4	3
July	31	155	3	1	0	0	1	10	7
August	31	155	5	6	4	4	1	50	32
September	30	150	3	4	5	0	2	36	24
October	31	155	2	7	1	1	2	33	21
November	30	150	4	1	3	0	0	15	10
December	31	155	1	4	1	0	0	12	8

For 5 months of year results did not meet proposed standard.

58.3 per cent of time during 1918 we were able to meet the proposed standard.

365 samples collected during the year.

35 of those samples or 9.6 per cent of all the samples showed three or more positive portions out of five 10 cc. in every single sample.

—L. C. Billings.

Health Dept., Jacksonville, Fla.
May 17, 1923.

Jacksonville water is derived from a dozen or more flowing wells which are from an aquifer 900 feet below the surface. As the water runs from the wells it is germ free, but until a week ago it was aerated in an open basin to remove the sulphur and in this basin received enough aerial contamination to prevent it passing the test. Our basin has not been covered and it may be that in the future we can meet the proposed standard.

Although Jacksonville's water in the past would not meet the old standards or the proposed new standard, I am convinced that it has always been perfectly safe to use.

—*Horatio N. Parker.*

Missouri State Board of Health, Jefferson, Mo.
May 17, 1923.

The only other series of analyses of a single supply which we can furnish is for the supply of Jefferson City, Missouri. The following are the pertinent facts:

Ownership: Corporate; Capital City Water Company.

Source: Missouri River.

Treatment: Coagulation with lime and iron, settling, chlorination (maintain residual chlorine at downtown water office).

Laboratory Control: Three samples collected at about weekly intervals analyzed by Mr. W. F. Monfort, St. Louis, Mo.

Results of analyses May 1, 1922, to May 1, 1923: Number of samples examined, 151; number 10 cc. B. coli tubes, 755 positive, 19 or 2.5 per cent; number of samples in which 3 or more portions were positive out of 5 tubes, none.

Our observations would indicate that the filtration plants with chlorinators in the smaller Missouri municipalities can produce water which will easily conform to the old or new standard by making the simple o-tolidin test daily.

—*George W. Putnam.*

Montclair Water Co., Paterson, N. J.,
Little Falls, N. J.

We feel that the 10% of 10 cc. samples is fair enough, but think that taking of 5 portions of 10 cc. each of each sample is considerable of a burden where daily analyses are made. While our water will stand up to such a standard it appears to me to entail more work than is justified in our case.

You will note that positive bacillus coli results occurred but 5 times in 10 cc. in the past two years (730 samples) and had we made 3650 tests the results would not have been materially different.

July 1, 1919—10 cc.

TOTAL	NUMBER POSITIVE	PER CENT POSITIVE
614	209	34
590	176	30
491	135	37
365	80	22
365	18	5
366	31	8
365	14	4
365	27	7
365	35	10
366	73	19
365	55	15
365	22	6
365	10	3
366	16	4
365	0	0
365	5	1

—*Franklin W. Green.*

Louisville Water Co., Louisville, Ky.
May 7, 1923.

I am unable to give you actual figures for our plant that will be comparable to your proposed standard. The reason for this is that we just began planting five 10 cc. samples daily on the filtered water on Jan. 1st of this year. However, from a general study of our results for the past three years, I should say that we can just about meet this standard during the months of June, July, August and September. During the remaining months in the year we would have no trouble in keeping well within it.

—*W. H. Lovejoy.*

City of Milwaukee, Dept. of Public Works.
May 4, 1923.

Replying to your letter of April 28th, I am transmitting herewith Laboratory data of our treated water supply beginning February, 1919. Previous to this date tests for coli were not confirmed. You will notice that there were only a few months when we met the tentative standard proposed by your Committee.

Confirmed tests

Month	Number samples	Number 10 cc. portions	Number +10 cc. portions	Number −10 cc. portions	Confirmed tests. Per cent 10 cc. portions showing B. coli group
1919					
January					
February	28	140	40	100	28.6
March	31	155	59	96	38.1
April	30	150	64	86	42.7
May	31	155	41	114	26.5
June	30	146	17	129	11.6
July	31	155	9	146	5.8
August	31	155	28	127	18.1
September	30	150	23	127	15.3
October	31	151	17	134	11.3
November	30	150	33	117	22.0
December	30	150	20	130	13.3
Years average	33	151	32	119	21.2
1920					
January	83	271	45	226	16.6
February	41	123	14	109	11.4
March	62	186	71	115	38.2
April	74	222	51	171	23.0
May	57	171	31	140	18.1
June	77	231	67	164	29.0
July	71	213	85	128	39.0
August	73	219	49	170	22.4
September	65	195	32	163	16.4
October	71	213	37	176	17.4
November	65	195	11	184	5.7
December	74	222	57	165	25.7
Years average	68	205	46	159	22.0

MONTH	NUMBER SAMPLES	NUMBER 10 cc. PORTIONS	NUMBER +10 cc. PORTIONS	NUMBER −10 cc. PORTIONS	CONFIRMED TESTS. PER CENT 10 cc. PORTIONS SHOWING B. COLI GROUP
1921					
January	69	207	42	165	20.3
February	62	186	18	168	9.7
March	69	207	39	168	18.8
April	67	201	51	150	25.4
May	64	192	31	161	16.1
June	70	210	11	199	5.2
July	62	186	14	172	7.5
August	75	225	49	176	21.8
September	70	210	51	159	24.3
October	62	186	53	133	28.5
November	64	192	20	172	10.4
December	68	204	31	173	15.2
Years average	67	200	34	166	16.9
1922					
January	67	201	31	170	15.4
February	61	183	45	138	24.6
March	64	192	69	123	35.9
April	61	183	79	104	43.2
May	69	207	46	161	22.2
June	73	219	38	181	17.4
July	63	189	37	152	19.6
August	74	222	57	165	25.7
September	65	195	35	160	18.0
October	73	219	50	169	22.8
November	68	204	78	126	38.2
December	63	189	86	103	45.5
Years average	67	200	54	146	27.4
1923					
January	68	204	35	169	17.2
February	56	168	19	149	11.3
March	74	22	63	159	28.4
Average	66	198	39	159	19.0

—*H. P. Bohmann.*

City of Milwaukee, Dept. of Public Works.
May 9, 1923.

It would seem, after analyzing the new standard proposed, that it is not nearly as reliable for basing the pollution of a water as the Coli Index Method, now in use, although as a matter of fact we are unable to meet either standard.

A comparison between the results tabulated on per cent of confirmed 10 cc. portions with the B. coli indices for the same months show no uniform relation between the two.

1921	Number of samples containing 3 tubes + in 10 cc.	Per cent samples
June	2 in 70 samples	2.8
July	4 in 62 samples	6.4
August	10 in 75 samples	13.3
September	9 in 70 samples	12.8

—*H. P. Bohmann.*

St. Louis, Mo., May 9, 1923.

The data given on the four plants recently show the presence of confirmed tests for members of the colon group, including aerogenes and whatever gives lactose fermentation, Endo-positive, non-sporeforming results.

Bacterium coli Group. Positive Completed Tests in 10 cc. Portions

Positive results	A	B	B*	C	D	D*
0 in 5	368	183	125	136	94	94
1 in 5	37	46	10	29	32	32
2 in 5	7	11	2	1	4	4
3 in 5	4	12	0	0	5	2
4 in 5	8	11	0	0	5	1
5 in 5	0	0	0	0	0	0
Total number of samples	424	263	137	166	140	133
Total No. of portions	2120	1315	685	830	700	665
Portions	95	148	14	30	75	50
Per cent portions positive	4.48	11.26	2.04	3.65	8.51	7.52
Total number of samples	424	263	137	166	140	133
Samples positive in 3 or more of 5 portions	12	23	0	0	10	3
Per cent samples positive in 3 or more of 5 portions	2.83	8.74	0	0	7.14	2.25

The four plants furnishing data here given differ in procedure:

A. Alumina sulfate followed by filtration; hypochlorite of lime used.

B. Lime and iron sulfate without filtration; chlorine produced with an electrolytic cell.

B.* Same process as plant (B) after correcting irregularity in cell operation.

C. Lime and iron sulfate without filtration; liquid chlorine used.

D. Lime and alumina sulfate without filtration; liquid chlorine used.

D.* Same process as plant (D) after correcting adjustment of new chlorinator.

—*W. F. Monfort.*

Sewerage and Water Board of New Orleans, La.
May 8, 1923.

It would seem that the adoption of any standard to be met by water is very intimately connected with the methods of analysis employed; and in view of the fact that the standard methods are in process of revision by the American Public Health Association with the possible differentiation in the near future between the fecal and non-fecal sub-groups of the coli group, the standard adopted should designate the methods to be used, and should be flexible enough to meet any rational changes in the standard methods.

If records are based on samples taken from one point daily, it would require approximately a two months' period to cover the 50 samples on which the requirement under "1a" should be based, while if samples were taken twice daily, less than a month would be required.

Judging this standard by the results obtained at our two plants, detailed data from which are enclosed herewith, our filter effluent before chlorination has always been above it, when 50 daily samples are considered, or when a month period is considered also.

Bacillus coli tests

YEAR	MONTH	NEW ORLEANS								ALGIERS			
		Filter effluent (before chlorination)				Tap water (after chlorination)				Tap water (after chlorination)			
		Number samples tested	Number samples showing following number of positive portions			Number samples tested	Number samples showing following number of positive portions			Number samples tested	Number samples showing following number of positive portions		
			One	Two	Three or more		One	Two	Three or more		One	Two	Three or more
1918	October	30	3	0	0	25	2	0	0	25	0	0	0
	November	30	5	2	0	21	1	0	0	21	3	0	0
	December	30	4	4	0	24	1	0	0	22	2	0	0
Total.		90	12	6	0	70	4	0	0	68	5	0	0
Per cent of samples . . .			13.3	0.7	0		5.7	0	0		7.4	0	0
1919	January	30	6	6	0	24	0	0	0	24	0	0	1
	February	27	8	4	1	24	1	0	0	24	0	0	1
	March	30	3	3	0	24	1	0	0	25	0	1	0
	April	30	6	0	0	24	2	1	0	24	0	0	0
	May	31	7	3	0	27	1	0	0	27	1	0	0
	June	30	5	1	0	22	0	0	0	23	0	0	0
	July	31	2	2	0	26	1	0	0	26	1	0	0
	August	31	1	2	1	25	1	0	0	26	3	0	0
	September	30	7	0	0	24	1	0	0	24	2	0	0
	October	31	10	1	0	27	1	0	0	27	2	0	0
	November	30	2	1	0	22	0	0	0	22	1	0	0
	December	30	6	2	0	26	0	0	0	26	2	0	0
Total.		361	63	25	2	255	9	1	0	298	12	1	2
Per cent of samples . . .			17.5	6.9	0.6		3.5	0.4	0		4.0	0.3	0.7
1920	January	31	4	1	0	24	2	1	0	24	1	0	0
	February	27	2	0	0	20	0	0	0	20	1	0	0
	March	27	1	0	0	24	2	0	0	24	1	0	0
	April	29	3	1	0	23	3	0	0	23	0	0	0
	May	29	5	0	0	25	1	0	0	24	2	0	0
	June	30	0	0	0	25	1	0	0	25	0	0	0
	July	24	1	1	0	22	2	1	0	21	1	1	0
	August	31	1	0	0	26	0	0	0	25	0	0	0
	September	30	1	0	0	25	1	1	0	25	0	1	0
	October	31	2	0	0	25	0	0	0	25	0	0	0
	November	30	0	0	0	23	1	0	0	23	0	0	0
	December	30	0	0	0	26	0	0	0	26	0	0	0
Total.		349	20	3	0	288	13	3	0	286	6	2	0
Per cent of samples . . .			5.7	0.9	0		4.4	1.0	0		2.1	0.7	0

YEAR	MONTH	NEW ORLEANS								ALGIERS			
		Filter effluent (before chlorination)				Tap water (after chlorination)				Tap water (after chlorination)			
		Number samples tested	Number samples showing following number of positive portions			Number samples tested	Number samples showing following number of positive portions			Number samples tested	Number samples showing following number of positive portions		
			One	Two	Three or more		One	Two	Three or more		One	Two	Three or more
1921	January	31	4	0	0	24	0	0	0	24	0	0	0
	February	28	1	0	0	22	0	0	0	22	0	0	0
	March	31	1	2	0	26	0	0	0	26	1	0	0
	April	30	3	1	0	26	2	0	0	26	0	0	0
	May	31	4	0	0	26	1	0	0	26	2	0	0
	June	30	1	0	0	25	1	0	0	25	2	0	0
	July	30	5	2	0	22	2	1	0	25	4	0	0
	August	31	3	0	0	26	0	0	0	27	0	1	0
	September	30	3	0	0	25	1	1	0	25	2	0	0
	October	31	2	0	0	25	0	0	0	25	2	0	0
	November	29	1	0	0	23	1	1	0	23	1	0	0
	December	31	1	0	0	26	0	0	0	26	0	0	0
Total...............		363	29	5	0	296	8	3	0	300	14	1	0
Per cent of samples ...			8.0	1.4	0		2.7	1.0	0		4.7	0.3	0
1922	January	29	2	0	0	24	1	0	0	25	1	0	0
	February	27	1	0	0	22	0	1	0	22	0	0	0
	March	31	0	0	0	27	0	0	0	27	0	0	0
	April	30	2	0	0	22	0	0	0	25	0	0	0
	May	31	1	0	0	27	1	1	0	27	0	0	0
	June	29	0	0	0	24	1	0	0	24	0	0	0
	July	30	2	0	0	25	1	0	0	25	2	0	0
	August	31	2	2	0	27	1	0	0	27	0	1	0
	September	28	1	0	0	25	0	0	0	25	0	0	0
	October	29	1	0	0	23	0	0	0	23	0	0	0
	November	28	0	0	0	20	0	0	0	20	0	0	0
	December	27	6	0	0	22	0	0	0	23	1	0	0
Total.................		350	18	2	0	288	5	2	0	293	4	0	0
Per cent of samples...			5.1	0.6	0		1.7	0.7	0		1.3	0	0
1923	January	31	3	0	0	25	0	0	0	25	0	0	0
	February	28	1	0	0	22	0	0	0	22	0	0	0
	March	31	3	0	0	26	1	1	0	26	1	0	0
	April	27	0	0	0	22	0	0	0	22	0	0	0
Total.................		117	7	0	0	95	1	1	0	95	1	0	0
Per cent of samples...			6.0	0	0		1.1	1.1	0		1.0	0	0

—*Geo. G. Earl.*

Mt. Prospect Laboratory, Brooklyn, N. Y.
May 9, 1923.

As to #1 first paragraph: The City of New York—judging from its experience since the employment of plant control of chlorination during the last two years would find no difficulty in meeting the new specifications in samples taken immediately following chlorination, assuming that the specifications mean not more than 10% positive tests average of all tests made.

Average Analyses for 1922 at Various Points of Several of the Main Supplies of New York City

	Proposed new specifications 0.1 B. coli per 10 cc.	Bacteria per cc., 37°C.
Croton supply		
Croton Lake, effluent	0.4	20
Croton aqueduct, raw	11.15	72
Croton aqueduct, chlorinated	0.01*	27
Jerome Park Reservoir, effluent	0.04*	85
Central Park Reservoir, effluent (average of three)	0.3	61
Tap, Manhattan	0.14	44
Catskill supply		
Ashokan Reservoir, effluent	0.16	69
Kensico effluent, raw	1.15	15
Kensico effluent, chlorinated	0*	3
Hillview effluent	0.3	12
Shaft no. 23, Brooklyn	0.5	16
Tap, Brooklyn, intermediate service	0.2	18
Tap Long Island City	0.5	13
Tap Flushing (mixed with walls)	0.5	16
Tap, Richmond low service	0.5	66
Long Island supply		
Chlorinated	0.02*	20
Ridgewood Pumping Station	0.3	38
Ridgewood Reservoir surface (average of three)	3.0	77
Tap, Brooklyn, low service	0.2	23
Richmond wells		
Clove Wells chlorinated	0.02*	103
Boulevard Wells chlorinated	0.02*	6
Tap, Richmond, intermediate service	0.1*	27
Tap, Richmond, high service	0.2	29

* Meet the proposed specification.

With regard to tap samples in the City—even the present specifications cannot be met. The reason for this is due to deposition of B. coli in the sediment followed by occasional disturbance of the sediment due to fires, reverse currents, etc. Also B. coli appears in the distribution reservoirs due to disturbance of sediment, contamination from birds, (seagulls, etc.), dust from the streets and growth of B. coli in the water due to increase of temperature in the summer.

—*Frank E. Hale.*

State Board of Health, Concord, N. H.
May 2, 1923.

With regard to the proposed B. coli standard I assume that by "10% of all the ten cubic centimeter portions examined" is meant the total number of 10 cc. portions for a given period, such as a year. While we feel that most of our New Hampshire supplies represent very satisfactory character yet there are a number of our cities that seems to be having difficulty in meeting the present twenty per cent requirement.

While I have not the information at hand concerning all of our public supplies, I am appending the ten cc. results for our cities on samples as collected during the past two years:

CITY	PERCENTAGE OF ALL 10 CC. PORTIONS POSITIVE
Berlin	26.5
Claremont	7.4
Concord	8.8
Derry	0.0
Dover	19.2
Franklin	0.0
Keene	24.2
Laconia	21.3
Manchester	31.2
Nashua	3.2
Portsmouth	0.0
Rochester	9.1
Somersworth	18.5

With regard to the above it should be noted that Dover, Somersworth and Laconia have recently installed modern type chlorinators and their results will undoubtedly run better in the future. The supplies of Keene, Manchester and Berlin are undoubtedly in need of chlorination.

With regard to the second division of the proposed B. coli standard, I am not quite certain at this time as to just how this would coincide with our experience. Off hand, it impresses me as being a bit rigid.

—*Charles D. Howard.*

Bureau of Water, Pittsburgh, Pa.
May 21, 1923.

We trust this report will supply the information you desire; if it does not, we shall be pleased to supplement it with further data which may be available here.

—James I. Brennan.

The writer has been in rather close touch with the data for many years, paying particular attention to the relative significance of Aerogenes under our local conditions, and he is convinced that the interpretation of these data would hardly show any material change from the presentation of data for a longer period unless it be to conclude more forcibly that the definition of coli, as presented in your letter, is entirely too broad to permit the best interpretation of the sanitary quality of a water supply.

For the purpose of bringing out as far as possible the real key to the situation, the data for the sixteen months covered, are presented under two heads.

1. Chlorinated Waters, meaning chlorinated water as delivered from the purification plant.

2. Distribution system, meaning this same water as it is delivered to the consumer throughout the city after being pumped and passing through distributing reservoirs and pipe lines.

TABLE 1

Frequency of 10 cc. positive tests for colon group

Month	Year	Chlorinated water			Distribution system		
		Number samples	Number positive 10 cc.	Per cent positive 10 cc.	Number samples	Number positive 10 cc.	Per cent positive 10 cc.
January	1922	139	6	4.3	372	17	4.6
February	1922	127	9	7.1	337	6	1.8
March	1922	137	2	1.5	398	15	3.8
April	1922	137	1	0.7	349	13	3.7
May	1922	142	1	0.7	387	23	5.9
June	1922	139	3	2.2	378	33	8.7
July	1922	141	1	0.7	369	18	4.9
August	1922	147	1	0.7	398	18	4.5
September	1922	132	0	0.0	362	15	4.1
October	1922	141	27	19.1	385	53	13.8
November	1922	140	24	17.1	373	44	11.8
December	1922	141	34	24.0	358	100	27.9
January	1923	144	1	0.7	382	13	3.4
February	1923	128	0	0.0	339	0	0.0
March	1923	140	3	2.1	371	4	1.1
April	1923	138	0	0.0	359	2	0.6

It has been our custom for a number of years, since using the eosine methylene blue plate, not to carry further such cultures as, from experience and many tests, we could be certain were Aerogenes.

For the period covered in table 1 from January, 1922, to October, 1922, inclusive, our summary records do not show the distinction between the

TABLE 2

Negatives by eosine methylene blue plate 85 per cent of which probably in colon group

1922	CHLORINATED WATER		DISTRIBUTION SYSTEM	
	Negative E. M. Agar	Estimate 85 per cent colon group	Negative E. M. Agar	Estimate 85 per cent colon group
January	0	0	4	3
February	0	0	1	1
March	0	0	0	0
April	0	0	1	1
May	0	0	9	8
June	1	1	30	25
July	3	3	58	49
August	4	3	30	25
September	2	2	37	31
October	8	7	57	44

TABLE 3

MONTH	YEAR	CHLORINATED WATER			DISTRIBUTION SYSTEM		
		Number samples	Number positive 10 cc.	Per cent positive 10 cc.	Number samples	Number positive 10 cc.	Per cent positive 10 cc.
January	1922	139	6	4.3	372	20	5.4
February	1922	127	9	7.1	337	7	2.1
March	1922	137	2	1.5	398	15	3.8
April	1922	137	1	0.7	349	14	4.0
May	1922	142	1	0.7	387	31	8.0
June	1922	139	4	2.9	378	58	15.3
July	1922	141	4	2.8	369	67	18.2
August	1922	147	4	2.7	398	43	10.8
September	1922	132	2	1.5	362	46	12.7
October	1922	141	34	24.1	385	97	25.1
November	1922	140	24	17.1	363	44	11.8
December	1922	141	34	24.0	358	100	27.9
January	1923	144	1	0.7	382	13	3.4
February	1923	128	0	0.0	339	0	0.0
March	1923	140	3	2.1	371	4	1.1
April	1923	138	0	0.0	359	2	0.6

plate cultures marked negative because of Aerogenes and those marked negative for some other reason.

Consequently for the first ten months of that table only Aerogenes found in the subcultured tests are included in the positive tests interpreted according to the definition of the colon group given.

I have therefore prepared another tabulation for this period showing the additional 10 cc. tests which were found positive in the preliminary fermentation and which had been reported negative by the eosine methylene blue plate.

Our experience has shown that approximately 15% of these would have been demonstrated not to belong to the colon groups. The balance 85% would have been largely Aerogenes. This estimation is also shown in table 2.

For your convenience, I have prepared table 3 which is table 1 corrected with the data from table 2.

The data given in table 3 is therefore a very close estimate of the results on single 10 cc. tests from a sufficiently large number of samples to indicate how nearly we would meet the first specification of the proposed U. S. Public Health Standard under local conditions.

It should be stated that we use a lactose bile instead of lactose broth for the *preliminary* fermentations.

Our standard formula contains 1.5% dry oxgall and all ingredients are doubled for 10 cc. tests as is also the quantity of media per tube.

—*W. U. C. Baton.*

City of Philadelphia, Bureau of Water.
April 30, 1923.

I believe the standard is altogether too rigid for routine examinations. We operate our plants not so much from the total number of positive B. Coli as from the types found. We can pick up weak strains at any part of the distribution system by changing or reversing the flow of water through the mains. These weak strains are not considered significant as far as plant operation is concerned; neither are they considered significant in the plant effluent when the agar count is low; by low we mean single figures.

B. coli filtered water basins per cent of time positive in 10 cc. single daily samples

YEAR	TORRESDALE		QUEEN LANE			BELMONT		UPPER ROX		LOWER ROX		TOTAL M.G.D.	TYPHOID DEATH RATE
	Per cent positive	M.G.D.	North—per cent positive	South—per cent positive	M.G.D.	Per cent positive	M.G.D.	Per cent positive	M.G.D.	Per cent positive	M.G.D.		
1922	14.9	191	9.3	11.8	56	18.1	46	17.9	14	13.5	8	314	2.8
1921	20.7	180	24.4	20.9	54	20.3	43	20.2	14	21.4	8	300	2.2
1920	12.0	190	44.6	43.6	61	37.6	46	35.8	14	38.2	8	319	3.4
1919	6.0	185	33.0	35.6	59	24.6	45	24.7	14	25.5	7	311	4.5
1918	7.0	190	17.5	18.1	62	25.8	44	13.7	14	20.2	10	319	4.8

M.G.D., million gallons per day filtered.

I am enclosing a table which I have made up according to your suggestion. Previous to 1918 the percentage is lower because we reported the B. Coli Communis instead of the B. coli group. I have added to this table of percents positive, the average million gallons filtered per day at the various plants; the total amount filtered per day at all plants and the death rate. These percents positive represent the number of days the 10 cc. sample was positive during the year. Three hundred and sixty-five samples were taken at each plant.

—*Lyle L. Jenne.*

City of St. Louis, Water Division.
April 30, 1923.

YEAR	10 CC. PORTIONS—NUMBER OF SAMPLES EXAMINED	NUMBER POSITIVE	PER CENT POSITIVE
1913–14	529	47	8.9
1914–15	1181	72	6.1
1915–16	1196	104	9.5
1916–17	1094	76	6.9
1917–18	1092	49	4.5
1918–19	1098	58	5.3
1919–20	1094	69	6.3
1920–21	1102	87	7.9
1921–22	1100	49	4.5
1922–23	1090	34	3.1

Samples are obtained twice a day from two reservoirs. One fifty, one ten and two one cubic centimeter quantities are planted in lactose broth on each sample.

The figures given were obtained by the use of the method given in your letter; lactose fermentation, characteristic growth on Endo and secondary fermentation of lactose broth.

—*A. V. Graf.*

Department of Public Health, Toronto.
May 3, 1923.

Replying to yours of the 28th, I give below the figures (percentage positive confirmed B. coli) of samples examined immediately after filtration in Toronto, for the past ten years.

Slow-sand filtered water—10 cc.

1913	7.5	1918	17.2
1914	8.9	1919	27.4
1915	11.1	1920	46.7
1916	11.5	1921	44.6
1917	14.4	1922	33.0

Drifting-sand (mechanical) filtered water

1918	52.1	1921	46.4
1919	60.0	1922	33.7
1920	60.9		

The quality of the raw water has got steadily worse during recent years, and the percentage increase of B. coli in 10 cc. amounts, has followed the same curve. The drifting sand effluent is of little value in making any deduction as the water is treated with either alum or chlorine according to the quality of the raw water. In 1922 intensive pre-chlorination was practiced showing excellent results.

In waters which do not show any great variation in pollution, it would seem possible to keep within the standards of the U.S.P.H. standards, but in waters similar in character to those of the Great Lakes, many of which show enormous fluctuations in quality, altering from hour to hour, I do not think it practical or possible to try and attain such a high standard of purity.

—*Norman J. Howard.*

City of Toledo, Division of Water.
May 4, 1923.

The Phelps method has been in use at this laboratory for years and the index reported as yearly average has been less than the standard of 2 bacillus coli per 100 cubic centimeter for the greater portion of the time. During the years 1916 and 1917 this index was very high and was due entirely to conditions arising from discontinuing a lime softening treatment which left the filters and all equipment practically wrecked. This condition was not entirely remedied until late in 1917.

In 1922 due to insufficient time for coagulation the filter burden was increased during certain periods of the colder months when chemical reactions were slow. With the practical completion of a new coagulation basin it is our belief that the 1914 standard can be met at this plant without difficulty.

B. coli index per 100 cc.

	1915	1916	1917	1918	1919	1920	1921	1922
Disinfected water	0.72	10.89	8.42	0.79	0.42	1.31	1.48	2.81

The above determinations were based on the presence of any quantity of gas whether less than 10% or over and the smallest quantity showing positive confirmed with Endo; transplant, etc. Not less than two determinations each 24 hours are made in every stage of the process and the yearly average figures are taken from these data.

—*F. W. Furman.*

State Board of Health, Richmond, Va.
May 2, 1923.

In a number of instances we certify the waters as being satisfactory for use on railway trains when the percentage of samples containing B. coli is greater than what you indicate.

Railroad water supplies

Bacteriological Results for Samples Examined in the Laboratory for the State Board of Health. Samples are collected in 2 oz. glass-stoppered bottles sterilized in the laboratory. Intervals between the time of collection and time of delivery vary from 12 to 48 hours. The certification of the supply depends on the findings of the sanitary survey as well as the bacterial results. Samples are shipped by parcel post and not iced.

From September 30, 1922 to date

PLACE	SOURCE	TREATMENT	NUMBER OF TESTS	PER CENT OF B. COLI CONFIRMED		
				1 cc.	10 cc.	50 cc.
Alexandria*	Watershed	Fil.-Cl.	152	0	1.9	
Abingdon	Springs	Cl.	5	0	0	0
Appalachia	Watershed		3	0	0	0
Blacksburg	Spring	Cl.	1	0	0	0
Bristol	Springs	Cl.	15	0	0	0
Cape Charles	Wells		8	0	0	0
Charlottesville	Watershed	Fil.-Cl.	9	0	0	0
Clifton Forge	Watershed		2	0	50	0
Covington	Watershed	Cl.	2	0	0	0
Crewe	Wells		4	0	0	0
Danville	Dan River	Fil-Cl.	12	0	0	0
Elkton	Spring		1	0	0	0
Emporia	River	Fil-Cl.	13	0	0	0
Fredericksburg	Watershed	Cl.	7	0	29	
Gordonsville	Springs		2	0	50	
Harrisonburg	Dry River		2	0	0	0
Hot Springs	Springs		29	0	20	
Keysville	Well		2	0	0	0
Lawrenceville	Creek	Fil.-Cl.	16	0	0	0
Lexington	Watershed		2	0	0	0
Leesburg	Spring and well		8	37	75	
Luray	Watershed	Cl.	7	0	28	
Lynchburg*	Watershed	Fil.	146	0	0	0
Marion	Springs		5	0	0	0
Martinsville	Creek	Fil.-Cl.	17	5	28	
Newport News*	Lakes and watershed	Fil.-Cl.	126	0	0	0
Norfolk*	Lakes	Fil.-Cl.	182	0.05	8.7	
Norton	Creeks		6	33	33	
Petersburg*	River	Fil.-Cl.	122	0.8	5.7	
Pocahontas	Creek	Cl.	7	0	0	0
Portsmouth	Lakes	Fil.-Cl.	12	0	0	0
Pulaski	Wells	Cop.-Sul.	3	0	0	0
Radford	River	Fil.-Cl.	15	6	26	
Richmond	River	Fil.-Cl.	257	0	0	0

* Analyses made in City Health Department's office.

Place	Source	Treatment	Number of tests	Per cent of B. coli confirmed		
				1 cc.	10 cc.	50 cc.
Roanoke	Springs	Cl.	26	0	0	0
Salem	Springs	Cl.	8	0	50	
Saltville	Springs	Cl.	33	3	21	
Shenandoah	River	Fil.-Cl.	7	0	0	0
Warrenton	Wells		6	16	33	
West Point	Wells		3	0	0	0
Winchester	Rouss Spg.	Cl.	9	11	22	
Victoria	Well		3	0	0	0

—*Richard Messer.*

Conservation Commission, Albany.
May 10, 1923.

I have computed the percent $\frac{3}{5} \times \frac{4}{5} \times \frac{5}{5}$ tubes positive for different coli contents and figured the values for distribution curves I and II already sent. Curve I would give 4.5% and curve II 7.5%. The *standard* variability curve given in our memorandum—parallel to the London curve on the chart is approximately 8%. You can see from this that the value of 5% for the 2nd criterion is not too high. I believe 7.5% is more representative of *standard* practice and if it was for me to decide would certainly suggest it. However, if that value is chosen the second criterion is superfluous—and if anything lower is chosen the first criterion is superfluous. For this reason I should prefer to abandon the second entirely and stick to one—the first, I am enclosing my figures computed according to Reed which are the same as McCrady gave already.

B. coli per 100 cc.	0.1	0.2	0.3	0.5	0.7	1.0	2.0	3.0	5.0	7.0	10.0
Per cent + 10 cc. portions	1	2	3	5	7	10	18	26	39	50	63
Per cent samples 3 or more positive portions	0.001	0.008	0.03	0.12	0.32	0.85	4.5	12	33	51	76

From this table it is evident that the zero cases are quite indeterminate, i.e., would require 100 years without one sample + in $\frac{3}{5}$ or more to become determinate. The table given in the report checks the above conclusions and admirably illustrates the absurdity of the old 2% criterion. Also the smallest possible per cent $\frac{3}{5}$ or more samples for 20% of the tens would be more than 5%.

—*Wm. F. Wells.*

Water and Light Dept., Wellsville, N. Y.
May 3, 1923.

Unfortunately the records of this department do not allow any comparison prior to December 1921, at this time a rapid sand filter plant was placed in operation.

During the time stated but one sample of the tap water has confirmed 4 out of 5-10 cc. portions, two samples 2 out of 5 and the remainder 1 out of 5. In our routine work we follow the "Standard Methods" as far as recording results, but for our personal information we use the E.M.B. Media.

—*E. J. Rowe.*

Conservation Commission, State of New York.

What I have studied very carefully is the relation of one determination to another and unless this is carefully considered it will not make much difference what one is if the other rules. In this case the 2nd criterion ruled and still rules—so it seems to me that the 2nd is the one that needs watching first. For instance with the old value 2% *3 or more* 10 cc. you could set the per cent of 10 cc. as low as 5 and it would not affect a single ruling in the list they gave. While we were arguing on whether it should be 10% we would have let them slide in a rider actually putting it well below 5%.

We have not sufficient data yet to say exactly what condition corresponds to 10%, but I have written you two basic reasons for thinking that 5% *3 or more* 10 cc. is more rigid than 10% 10 cc. First, from the theory of variation based on supplies where it could be determined and second from the actual cases taken from their table, I believe the value should come between 7 and 8% $\frac{3}{5}$ or more 10 cc.

If the per cent 10 cc. is raised the other should be also in at least the same proportion. The two would be about alike at 20% 10 cc., that is, 20% *3 or more* 10 cc. In fact it seems to me that *before* arriving at a value 5 for the second criterion that more data should be gathered and studied. If a real question of the first criterion is mentioned surely the 2nd criterion should not be allowed to settle the question against the water works man just because it is overlooked and unfamiliar. In any case I feel satisfied that raising it from 2% to 5% is at least a step in the right direction and that after experience with the 2nd criterion the issue will settle on that as the more rigid of the two.

—*Wm. Firth Wells.*

SOCIETY AFFAIRS

THE ANNUAL CONVENTION

The Forty-Third Annual Convention opened officially on Tuesday, May 22, 1923, at the Hotel Statler, Detroit, Michigan, with an unprecedented registration of members and guests, totalling in the neighborhood of 1300 persons. The official opening was preceded as usual by informal sessions on Monday afternoon and evening, and a well-attended reception and dance on Monday evening at the Hotel Stratler. Particularly successful were the sessions held on Monday by the superintendents and operators, presided over by D. R. Gwinn, and the meetings held in the offices of the Board of Water Commissioners of the City of Detroit on the question of water works accounts, records and reports, under the leadership of G. H. Fenkell.

Morning session, May 22. Presiding officer, President Cramer. In the absence of an opposition ticket, the following list of officers elected was read: President, G. W. Fuller; vice-president, F. C. Jordan; treasurer, W. W. Brush; trustee, E. E. Wall; trustee, C. R. Bettes.

The following order of presentations took place:

Presidential Address,[1] by W. S. Cramer.

Report of Standardization Council,[2] read by G. W. Fuller; accepted.

Report of Committee on Standard Form of Contract,[3] read by J. Waldo Smith; tentative report approved and committee continued.

Address on Business Conditions, by Mortimer P. Lane, representing the United States Department of Commerce.

Address of Welcome, by Sheriff Walters and Francis L. Sward, president of the Board of Water Commissioners of Detroit.

The Use of Constant and Variable Speed Motors for Driving Water and Sewage Pumps, by F. L. Adams.

Water Works Pumping Stations, by Charles B. Burdick.

Determining the Proper Equipment for Pumping Stations,[4]

[1] See page 753 of this Journal.

[2] Journal, May, 1923, page 450.

[3] Journal, July, 1923, page 695.

[4] See page 756 of this Journal.

by Arthur L. Mullergren; discussion by J. N. Chester, A. U. Sanderson and the author.

Afternoon session, May 22. Presiding officer, President Cramer. The papers presented were:

Records of Stream Flow, Their Use and Best Methods of Obtaining them for Municipal and Industrial Purposes,[5] by C. C. Covert.

Collection and Daily Publication of Meteorological Data, by Scotland G. Highland.

Some Recent Large Water Works Projects, by Dabney H. Maury.

Following the above papers, the resolution given below was presented by T. A. Leisen, as passed by the Executive Committee. After favorable discussion by G. W. Fuller, E. Bartow and J. N. Chester, the resolution was unanimously adopted by the Association.

Whereas, the United States Department of Justice has instituted suits against certain contractors for cantonments built early in American participation in the World War, for recovery of large sums claimed to have been paid wrongfully to these contractors, and

Whereas, certain individuals indicted by a Federal Grand Jury for alleged criminal acts in connection with the construction of army cantonments are now awaiting trial, with the United States Department of Justice as prosecutor, and

Whereas, many members of the American Water Works Association were associated in one way or another with the work of the Construction Division of the United States Army and both their character and their ability must remain under a cloud until these cases are tried, and

Whereas, the Association is duly appreciative that no death from water-borne disease occurred among the four million troops at the numerous army camps, and of the many serious difficulties overcome with great speed in the summer and autumn of 1917 in adapting the emergency procedures of private construction work to supplying water and other facilities so vitally needed for the training of troops during the winter of 1917–18, and

Whereas, certain of the procedures which are enumerated as a cause for the criminal indictment of Col. W. A. Starrett and his associates have long been regarded as desirable, legitimate methods of conducting construction work under certain conditions so that this indictment of established practice of long standing in connection with public utilities and private construction is unwarranted, therefore be it

Resolved by the American Water Works Association, assembled in annual convention, that the earliest practicable trial of these suits and the indicted individuals shall be requested in the name of this Association, of the Attorney General of the United States, and that a copy of this resolution shall be sent to the President of the United States.

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[5] See page 778 of this Journal.

The last paper on the afternoon program was: The Design of the Proposed Water Filtration Plant at Baltimore,[6] by James W. Armstrong.

The members of the Nominating Committee were announced as follows: District 1, A. U. Sanderson; District 2, J. M. Caird; District 3, C. R. Wood; District 4, D. H. Maury; District 5, J. E. Gibson; District 6, F. D. H. Lawlor; Chairman, E. Bartow.

Evening session, May 22. Presiding officer, George H. Fenkell.

Two papers were presented, as follows:

The Water Works of Detroit, by George H. Fenkell.

Detroit Filtration Plant, by Theodore A. Leisen.

Morning session, May 23. Presiding officer, President Cramer.

The papers follow:

Recent Water Developments at Memphis, by J. R. McClintock.

A Rational Method of Paying for Water Works Construction, by C. M. Saville.

Municipal Team Work, by Frank C. Jordan.

Secretary Diven then read the report of the Convention Committee on the application of cities for the next convention, 1924. Memphis, Tenn., was chosen as the convention city.

Afternoon session, May 23. The members and guests attended a luncheon at the Detroit new water filtration plant through the courtesy of the Board of Water Commissioner. After luncheon, the party traversed Lake St. Clair and the St. Clair Flats in a lake boat, provided through the courtesy of the Water Works Manufacturers' Association, under the supervision of J. E. O'Leary.

Evening session, May 23. Presiding officer, President Cramer.

The program, arranged by the Water Works Manufacturers' Association, was as follows:

Manufacture of 20 inch Gate Valve, (moving pictures), by James H. Caldwell.

Making It Lighter and Making It Better, (moving pictures of manufacture of cast iron pipe), by J. D. Capron.

Installation and Recovery of Brass Well Screens, (moving pictures), by D. R. Johnson.

After the session adjourned, the members attended the smoker, under the auspices of the Manufacturers' Association, at the building of the General Motors Corporation. The ladies were the guests of the same body at a theatre party.

[6] Journal, July, 1923, page 535.

Morning session, May 24. Presiding officer, President Cramer. The program follows:

Iodine Treatment of a Water Supply for Prevention of Goitre,[7] by B. C. Little; discussion by W. A. Sperry and the author.

Vice-president Fuller takes the chair during presentation of the following reports of committees of the Standardization Council:

Watershed Protection,[8] read by H. E. Moses, in absence of W. L. Stevenson, chairman of the Committee; discussion by A. Hazen, J. N. Chester, H. F. Ferguson, C. M. Saville, G. R. Taylor, B. C. Little, H. Rosentreter, L. M. Anderson, C. A. Holmquist and W. S. Cramer.

Industrial Wastes in Relation to Water Supply,[9] read by A. L. Fales, chairman; discussion by E. Bartow, J. N. Chester, C. A. Emerson, Jr., H. P. Bohmann, C. M. Saville, L. H. Enslow, L. L. Jenne, E. C. Trax, C. M. Baker, R. S. Weston and H. F. Ferguson.

At this point the following resolution, introduced by D. R. Gwinn, was passed unanimously.

WHEREAS, it is becoming more and more the custom to set apart certain days of the year for the advancement and promotion of matters of public importance, as for instance, Fire Prevention Day, Mothers' Day, throughout the land, and so on; and

WHEREAS, the health and comfort of the people depend upon the purity and abundance of their water supply, and

WHEREAS, there is too little knowledge by the people in general, as regards the water supplies of their cities and towns, therefore, be it

Resolved, that this association favors the setting apart of a certain day of the year—the exact date to be decided by the executive committee—to be known as Water Works Day, and further be it

Resolved, that it is recommended that such day be observed throughout the land and in every city and town as far as convenient and possible by the throwing open of the water works plants to the public, and inviting of the citizens to visit the plant; by addresses to the public schools on the subject of the water supply; by meetings of the chamber of commerce, boards of trade, Rotary, Kiwanis and other clubs, with addresses on the subject, and by bringing the subject of the water supply before the people in every possible way on that day.

The committee reports were then continued, as below:

Standard Specification for Cast Iron Pipe,[10] read by F. A. Barbour,

[7] Journal, July, 1923, page 556.
[8] Journal, May, 1923, page 453.
[9] Journal, May, 1923, page 415.
[10] See page 866 of this Journal.

chairman; discussion by W. W. Brush, T. H. Wiggin, E. E. Wall, W. C. Hawley and C. M. Saville.

Steps toward Standardizing Stated Quantities for Slides in Meter Schedules,[11] read by I. S. Walker, secretary; discussion by J. N. Chester and A. Hazen; report adopted.

Afternoon session, May 24. Presiding officer, Vice-president Fuller.

The following names were proposed by Vice-president Fuller for election as honorary members of the Association. The proposal received unamimous approval and these men were elected:

Sir Alexander C. Houston, Director of Laboratories, Metropolitan Water Board, London, England.

George H. Benzenberg, Consulting Engineer, Milwaukee, Wisconsin.

Desmond H. Fitzgerald, Consulting Engineer, Brookline, Mass.

Rudolph Hering,[12] Consulting Engineer, New York, N. Y.

J. H. Purdy, American Water Works and Electric Co., New York, N. Y.

Wm. H. Mulholland, Chief Engineer, Dept. of Public Service, Los Angeles, California.

The reports of the Finance and Publication[13] Committees were adopted.

J. H. Gregory presented a resolution suggesting to the Water Commissioners of San Francisco that they rescind their action naming the Hetch Hetchy Dam the O'Shaugnessy Dam, in honor of M. M. O'Shaughnessy, since the Columbus, Ohio, dam had already been designated the O'Shaughnessy Dam after Jerry O'Shaugnessy. On motion, the resolution was lost.

The report of the Committee on Essential Data for Water Works Records and Reports from Municipal Plants[14] was read by G. H. Fenkell, chairman; discussion by J. N. Chester and G. W. Fuller.

Report of Committee on Standards for Satisfactory Drinking Water, read by Editor Wolman, in absence of A. W. Freeman, chairman.

Editor Wolman then presented in outline the tentative report of the Bacteriological Sub-Committee of the Advisory Committee on

[11] See page 871 of this Journal.

[12] Deceased.

[13] Journal, July, 1923, page 706.

[14] Journal, July, 1923, page 462.

Water Supply Standards of the United States Public Health Service. The report was discussed by H. E. Jordan, M. H. McCrady, C. A. Emerson, Jr., A. L. Fales, E. S. Chase, C. M. Baker, W. W. Brush, F. E. Hale, N. J. Howard, J. R. Baylis, H. F. Ferguson, R. C. Bardwell and A. Wolman. No action on the report was taken, pending further discussion by the members of the Association.

Report of Committee on Standard Methods of Water Analysis,[15] read by J. J. Hinman, Jr., chairman; in the discussion thereof, G. W. Fuller announced the plans of the Standardization Council for future negotiation with the American Public Health Association for the preparation of joint methods of laboratory procedure.

Report of the Committee on Practical Ranges in Loading for Water Purification Processes,[16] read by E. E. Wall, chairman; discussion by R. C. Bardwell.

Report of Committee on Colloid Chemistry in Relation to Water Purification,[17] by R. S. Weston, chairman; discussion by L. I. Birdsall and R. S. Weston.

Afternoon session, May 24. Superintendents' Meeting. Presiding officer, President Cramer.

The first discussion of the afternoon was on the paper by C. M. Saville, on "A Rational Method of Paying for Water Works Construction," in which the following participated: D. R. Gwinn, J. E. Gibson, W. S. Patton, W. McEvoy, H. P. Bohmann, H. F. Blomquist, J. N. Chester, P. J. Hurtgen and C. M. Saville.

The paper on "The Clogging of Intakes by Fish,"[18] by Leonard Metcalf, was read by F. A. Marston; discussion by J. N. Chester, E. E. Davis, A. U. Sanderson, S. H. Taylor and A. V. Ruggles.

Averaging Bills, was then presented by W. C. Hawley and discussed by D. R. Gwinn.

As a part of the "Question Box" series, the discussions were as below:

Flush Hydrants in Congested Districts, discussion by C. M. Saville, D. R. Gwinn and S. H. Taylor.

Use of 4 inch Laterals and Fire Hydrants, discussion by C. M. Saville and S. H. Taylor.

Use of 4½ inch Steamer Connections, discussed by W. C. Hawley,

[15] See page 860 of this Journal.

[16] Journal, May, 1923, page 494.

[17] Journal, March, 1923, page 273.

[18] Journal, July, 1923, page 595.

W. S. Cramer, N. M. R. Wilson, J. E. Gibson, G. E. Shoemaker, J. W. McEvoy, A. S. Holway, G. F. Merrill, J. N. Chester, W. W. Brush, A. Milne, I. S. Walker, W. Luscombe and S. H. Taylor.

Who Pays for Hot Water Damage to Meter, discussion by J. N. Chester, Wm. Luscombe, J. W. Toyne and F. A. Marston.

Setting of Meters, discussion by J. N. Chester, S. H. Taylor, J. E. Gibson and G. E. Shoemaker.

Service Charge on Multi-Family House, discussion by J. N. Chester, W. C. Hawley, I. S. Walker, W. S. Patton, J. E. Gibson and J. W. McEvoy.

Evening session, May 24. Presiding officer, Vice-president Fuller.

The program follows:

Size of Taps and Services, discussion by W. W. Brush, H. P. Bohmann, E. S. Cole, C. S. Foreman, J. M. Diven and C. M. Saville.

Report of Committee on Pumping Station Betterments, by L. A. Day, chairman.

Report of Committee on Methods and Records of Water Waste Control,[19] by W. W. Brush, chairman.

Report of Committee on Physical Standards for Distribution Systems,[20] by L. Chivvis, in absence of G. G. Dixon, chairman.

Report of Committee on Standardization of Services, by J. M. Diven.

Morning session, May 25. Presiding officer, President Cramer.

Flushometer Toilets, discussion by J. N. Chester, W. S. Cramer and W. C. Hawley.

Location Records of Water Services, discussion by J. E. Gibson, J. Woolley, W. W. Brush, W. S. Cramer and D. R. Gwinn.

Demonstration of Water Softening, by C. P. Hoover.

Leakage and Unaccounted For Water, by J. N. Chester and E. E. Bankson; discussion by H. P. Bohmann, A. S. Holway, W. S. Cramer and J. N. Chester.

Use of Portable Air Compressor on Water Works Distribution System, by F. C. Amsbary.

Meter Card Index System, by Charles Fox.

The Effect of Industrial Uses of Water on Total Consumption, by J. W. Ackerman.

Afternoon session, May 25. Presiding officer, D. R. Gwinn.

[19] Journal, May, 1923, page 468.

[20] Journal May, 1923, page 492.

The Water Works Coal Pile, by D. H. Maxwell; discussion by J. W. Toyne, H. P. Bohmann and C. S. Denman.

A Possible Source of Income for Smaller Plants, by H. A. Dill; read by D. R. Gwinn.

Use of Fire Hydrants for Purposes Other Than Extinguishing Fires, by J. W. Toyne; discussion by D. R. Gwinn, W. C. Hawley, H. P. Bohmann, A. A. Milne, N. M. R. Wilson, S. H. Taylor, F. D. H. Lawlor and the author.

Copper Sulphate Treatment for Water Growths, discussion by G. W. Fuller, W. S. Cramer, W. H. Lovejoy, J. E. Gibson, L. Van Gilder, E. T. Cranch, F. D. H. Lawlor and A. A. Milne.

Training Schools for Filter Operators, discussion by W. C. Hawley, F. D. H. Lawlor, A. A. Milne, J. Chambers, A. V. Ruggles, E. E. Davis and G. W. Fuller.

Who Pays for Maintaining Services, discussion by O. E. Bulkeley, F. A. Bunks, J. N. Chester, W. S. Cramer and E. E. Davis.

Private Fire Protection Services, discussion by J. N. Chester, H. P. Bohmann and D. R. Gwinn.

Chemical and Bacteriological Section, evening session, May 24 Joint session with the Detroit Section of the American Chemical Society. Presiding officer, H. E. Jordan, chairman.

The papers read at this session were as follows:

The Hardness of American Municipal Water Supplies, by W. D. Collins.

The Relation of Hardness of Water Supply to Public Health, E. S. Chase.

The Pharmacology of Drinking Water,[21] by H. C. Hamilton; discussion by C. P. Hoover, F. E. Hale, E. L. Filby, W. A. Sperry, S. B. Applebaum and the author.

Corrosion of Hot Water Systems,[22] by C. R. Texter; discussion by F. E. Hale, Wm. Gore and the author.

The Removal of Dissolved Gases from Water, by J. R. McDermet; discussion by J. R. Baylis, S. B. Applebaum and W. H. Lovejoy.

Morning session, May 25. Symposium on the Application of Physico-Chemical Research to Plant Problems. Presiding officer, H. E. Jordan.

The papers follow:

Soluble Aluminum in Filter Effluents, by W. D. Hatfield.

[21] See page 773 of this Journal.

[22] See page 764 of this Journal.

The Composition of the Precipitate of Hydrous Alumina, by M. L. Miller.

Theories of Coagulation, by A. M. Buswell.

The Use of Acids with Alum,[23] by J. R. Baylis.

Optimum Hydrogen Ion Concentration for Coagulation of Various Waters, by G. F. Catlett.

Afternoon session, May 25. Presiding officer, H. E. Jordan.

Mixing Devices and Reaction Time, by C. P. Hoover; discussion by J. H. Gregory, W. A. Sperry, C. A. Brown, W. C. Lawrence, E. Bartow, F. H. Waring and the author.

The Use of Chlorine to Assist Coagulation, by R. S. Weston; discussion by L. L. Jenne, M. McCrady, A. F. Mellen, N. J. Howard, H. E. Jordan and the author.

Clarifiers, by Paul Hansen; discussion by S. B. Applebaum, H. E. Jordan and the author.

Recarbonation of Softened Waters, by N. S. Hill, Jr.; discussion by M. Pirnie, R. S. Weston and the author.

Filter Unit Details, by Malcolm Pirnie; discussion by W. Gore and W. D. Hatfield.

Corrosion of Underdrains, by W. D. Hatfield.

Micro-Forces, with Reference to Orientation and Curvature, by Frank Hannan.

The following officers, presented by the nominating committee, were unanimously elected: Chairman, A. L. Fales; Vice-chairman, N. J. Howard; Secretary, A. M. Buswell; Executive Committee, M. Pirnie, J. M. Baylis, A. V. Graf.

CORRECTION

"Determining Hydrogen-Ion Concentration for Filter Plant Operation," by W. D. Hatfield. In the paper with this title (This Journal, Vol. 10, No. 2, page 298, March, 1923), the sub-headings of the first four columns in table 1, page 302, should read as follows:

DROPS OF INDICATOR IN		DROPS OF BUFFER TO EQUALIZE LEVEL IN TUBES	
Alkali tube	Acid tube	Alkali	Acid

[23] Journal, May, 1923, page 365.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to page of the journal.

Water Supply from Gravel Strata. J. W. Toyne. Mun. Cty. Eng., **63**: 21–2, 1922. A log should be kept of every boring. Strainer mesh should be determined from the sand. Casing should be sunk to full depth and pulled back after strainer is placed.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Quantitative Data in Stream Pollution Investigations. E. B. Phelps. Mun. Cty. Eng., **63**: 22–4, 1922. Stream pollution should be studied from standpoint of wastes, whether injurious in themselves or by decomposition. Biochemical oxygen demand is a most helpful indicator and may be applied to stream pollution problems most successfully.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Misadventures in Water Supply at Saginaw, Mich. Mun. Cty. Eng., **63**: 24–7, 1922. History of Saginaw's effort to obtain a decent water supply.—*Langdon Pearse.* (*Courtesy. Chem Abst.*)

Industrial Effluent Disposal. Times Eng. Supplement. Can. Engr., **43**: 395, 1922. Eufflents from by-products gas works have given offense. They may be treated by passing liquor down a scrubber tower, in which steam rises upwards. 1 cu. ft. of scrubber packing is required per 240 gal. liquor.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Why There Should Be a Service Charge. J. W. Ackerman. N. Y. State Conference, May, 1922. Eng. Contrg., **58**: 109–11, 1922. Argument is presented for service charge in water works rates.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Floating Scaffold Speeds Up Water Tank Erection. Eng. Contrg., **58**: 72, 1922. A raft was used floating inside a tank 35 ft. diam. and 130 ft. high to erect and to paint.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Pneumatic Concreting of a Swiss Power Tunnel. Eng. Contrg., **58**: 77–8, 1922. Describes lining of tunnel to carry 80 lb. per sq. in. with heavy steel reinforcing.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Method of Constructing Intake Line with Spiral Riveted Pipe. Eng. Contrg., **58**: 107–8, 1922. The 1500 feet of pipe was floated out from shore length by length and sunk in place. Concrete anchors were placed every 100 feet.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Tight Flexible Joints for Submarine Pipe Lines. A. D. Flinn. Eng. Contrg., **58**: 111–2, 1922. In laying 36-inch ball and socket cast iron pipe, tight lead joints were hard to make until a method of forcing lead under pressure through 32 holes around bell was tried to fill shrinkage in poured lead.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Concrete Groined Arches for Reservoir Roofs. P. O. Macqueen. Am. Soc. C. E., Oct., 1922. Eng. Contrg., **58**: 91–97, 1922. Gives complete summary of method of design, and data on existing structures, with tables.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Typhoid Fever and Water Supply. Langdon Pearse and S. L. Tolman. Am. P. H. Assn., 1922. Pub. Works, **53**: 226, 1922. A review of conditions around the Great Lakes.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Cemeteries and Ground Water Supplies. Dept. Pub. Health, Mass., 1920. Pub. Works, **53**: 230, 1922. Where free CO_2 is less than 17 p.p.m. corrosion of water pipes need not be feared. CO_2 in ground water is increased by cemeteries.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Functions of State and Local Health Departments in Improving Sanitation. W. H. Dittoe. Ohio's Health, State Dept. Health, **13**: 9–10, 103, Sept.–Oct., 1922. Brief outline of functions of state and local health departments of Ohio in matters relating to water supply, sewerage, etc. In the case of proposed water supplies or improvements, the state health department is required to pass upon plans and local departments act in advisory capacity only. In the case of existing public water supplies the state department has general supervision and must be prepared to investigate supplies regularly, while local departments have certain duties in connection with examination and analyses of supplies to determine their purity and to keep the public informed thereof.—*E. S. Chase.*

Standard Contracts and Specifications. L. P. Wolff. The Bulletin, Minn. Federation of Architectural and Engineering Societies, **7**: 12, 11, Dec. 1922. Discussion and criticism of existing practices in preparation of contracts and specifications, with suggestions for improvements designed to promote good feeling and confidence between engineer and contractor and at the same time adequately safeguard the interests of the engineer's client.—*E. S. Chase.*

Again the Natural Sodium Sulfate Waters. E. Fleury. J. pharm. chim., **24**: 476–8, 1921. From Chem. Abst. **16**: 1486, May 10, 1922. Reply to Cazeneuve (C. A. 16, 462). Natural waters cannot have a constant composition, and analyses thereof merely give results of arbitrary calculations of saline groupings.—*R. E. Thompson.*

Practical Experiences with the Anti-rust Agent Hydrogarol. R. NOWOTNY. Oesterr. Chem. Ztg., **25**: 23–4, 1922. From Chem. Abst., **16**: 1511, May 10, 1922. Hydrogarol is an asphaltic paint which will adhere to damp rusty iron surfaces. It provides excellent protection against the action of acids, caustic and calcium hypochlorite.—*R. E. Thompson.*

Iron Corrosion. J. N. FRIEND. Surveyor, **62**: 1605, 246, 1922. It was observed that iron does not rust in dry air, in water only, in moist air at constant temperature, nor in steam, provided the steam is not superheated. Experiments on durability of paints showed that the nearer the color of the paint was to the red end of the spectrum the longer it was likely to last. Red, black and white paints behaved similarly in the dark, but in the light oxidation was very much more accelerated in the case of the white. Protection of steel from corrosion was best effected by the application of one thin and one thick coat of paint. In the case of surfaces exposed to the air an increase in the total thickness of the paint increased the protection, while with sub-aqueous surfaces there was an optimum thickness, above which corrosion increased enormously. The optimum thickness found in the sub-aqueous tests made was 7 to 9 pounds per 100 square feet. Mill scale prevents or retards corrosion, but the scale becomes damaged during erection and moisture then sets up corrosion.—*R. E. Thompson.*

The Criterion for Stable Flow of a Fluid in a Uniform Channel. H. LEVY. Proc. Roy. Soc. Edinburgh, **41**: 136–47, 1920–1. From Chem. Abst., **16**: 1524, May 20, 1922. Mathematical.—*R. E. Thompson.*

Electroadsorption as a Purely Chemical Phenomenon. I. M. KOLTHOFF. Kolloid-Z., **30**: 35–44, 1922. From Chem. Abst., **16**: 1352, May 10, 1922. The adsorption of ions by solids (or the dispersed phase of suspensoids) is regarded as a strictly chemical reaction in which one ion of a very slightly soluble salt is replaced by another ion to form a second difficultly soluble salt. Process analogous to exchange of bases in permutite.—*R. E. Thompson.*

The Scattering of Light.—Note on Wolski's Paper on Optically Empty Liquids. F. B. KENDRICK. J. Phys. Chem., **26**: 72–4, 1922. From Chem. Abst., **16**: 1362, May 10, 1922. In preliminary experiments Kendrick was unable to prepare "completely optically empty" water by filtration through collodion, as was claimed by Wolski (C.A. 15: 786). Water which did not show light discs (dust motes) in the ultramicroscope was found to scatter light when observed in Martin's apparatus (C.A. 14: 2878).—*R. E. Thompson.*

The Sensibility of Indicator Dyes at Temperatures Higher than Ordinary Temperatures. I. M. KOLTHOFF. Univ. Utrecht. Rec. trav. chim., **40**: 775–85, 1921. From Chem. Abst., **16**: 1369, May 10, 1922. The variations in sensibility to H- and OH-ions of a number of indicators at 70° are given. The variations are due to changes in the dissociation constant of the dyestuffs at different temperatures. The sensibility at intermediate temperatures may be determined by interpolation.—*R. E. Thompson.*

Titration of Moderately Strong, in the Presence of Very Weak, Acid or Bases. I. M. Kolthoff. Pharm. Weekblad., **59**: 129–42, 1922. From Chem. Abst., **16**: 1370, May 10, 1922.—*R. E. Thompson.*

The Effect of Hydrogen-Ion Concentration on the Determination of Calcium. A. T. Shohl. J. Bio. Chem., **50**: 527–36, 1922. From Chem. Abst., **16**: 1371, May 10, 1922. In the determination of calcium as oxalate, if the solution is of lower pH than 4.0, calcium oxalate is dissolved; and if higher than 5.6, magnesium ammonium phosphate is precipitated.—*R. E. Thompson.*

Colorimetric Determination of Hydrogen-Ion Concentration without Buffer. I. M. Kolthoff. Pharm. Weekblad., **59**: 104–18, 1922. From Chem. Abst., **16**: 1371, May 10, 1922. A colorimetric method of determining H-ion concentration with two-color indicators, methyl red, methyl orange, tropeolin 00 and neutral red, by comparison with standards prepared from iron and cobalt solutions, is described. When using the one-color indicators, phenolphthalein and p-nitrophenol, the intensity of the color is compared with solutions of the indicators in alkali of known strength.—*R. E. Thompson.*

The Problem of Selective Corrosion and the Dezincification of Brass. F. de Wurstemberger. Rev. metal., **18**: 687–712, 1921. From Chem. Abst., **16**: 1383, May 10, 1922. The corrosion of condenser tubes of turbine generators was shown to be an electrochemical action and the result of anodic solution and cathodic deposition of the metal. The different types of corrosion and methods of protection are discussed in detail.—*R. E. Thompson.*

The Determination of Hydrogen-Ion Concentration. F. H. McCrudden. Public Health Reports, **37**: 7, 334–48, 1922. From Chem. Abst., **16**: 1444, May 10, 1922. Excellent discussion of theory and practice of ionization and colorimetric pH determination, of particular value to bacteriologists.—*R. E. Thompson.*

The Action of Dilute Acids on Bacterial Growth in Optimum H-ion Concentration. I. W. Hall and A. D. Fraser. J. Path. Bact., **25**: 19–25, 1922. From Chem. Abst., **16**: 1446, May 10, 1922. Lactic and nitric (1 part normal acid to 166 parts of medium) generally act as a stimulant to growth, while salicylic, butyric and phosphoric acid delay the process.—*R. E. Thompson.*

The Physiology of the Respiration of Fishes in Relation to the H-ion Concentration of the Medium. E. B. Powers. J. Gen. Physiol., **4**: 305–17, 1922. From Chem. Abst., **16**: 1465, May 10, 1922. Ability of fish to absorb oxygen at low tension from sea water depends more or less on H-ion concentration of the water.—*R. E. Thompson.*

Oxygen Concentration as a Limiting Factor in the Respiratory Metabolism of Planaria Agilis. E. J. Lund. Biol. Bull. Marine Bio. Lab., **41**: 203–20, 1921. From Chem. Abst., **16**: 1466, May 10, 1922. Oxygen concentration becomes a limiting factor in the rate of oxygen consumption of P. agilis at about ⅓ air saturation of water at 20°.—*R. E. Thompson.*

Acidity Determination in Foodstuffs. L. Michaelis. Wochenschr. Brauerei, **38:** 107–8, 1921; Chimie et industrie, **7:** 141, 1922. From Chem. Abst., **16:** 1469, May 10, 1922. A simple colorimetric method of determining H-ion concentration is described.—*R. E. Thompson.*

Improving the Performance of Steam Boilers. R. de Kergaradec. Technique moderne, **14:** 14–21, 1922. From Chem. Abst., **16:** 1472, May 10, 1922. A discussion, largely mathematical, of chimney losses in boilers and methods of reducing such losses to a minimum, with special emphasis on the use of air preheaters, either with or without economizers.—*R. E. Thompson.*

Keeping Heating Surfaces Clean Electrolytically. B. Brukner. Deut. Zuckerind., **46:** 759, 1921. From Chem. Abst., **16:** 1473, May 10, 1922. The Cumberland electrolytic process of preventing scale formation, by the liberation of hydrogen on the surfaces of the boiler, is described. The boiler is made the cathode and an iron tube the anode, current being furnished from a 10-volt circuit.—*R. E. Thompson.*

The Sterilization of Drinking Water by Ozone. J. Muset. J. Pharm. Belg., **4:** 37–40, 53–55, 1922. From Chem. Abst., **16:** 1474, May 10, 1922. An ozoning apparatus which can be attached to any ordinary water faucet and which is capable of rendering water sufficiently sterile for drinking purposes, is described.—*R. E. Thompson.*

Investigation of Soil Pollution and the Relation of Various Types of Privies to the Spread of Intestinal Infections. I. J. Kligler. Intern. Health Bd., Monograph 15, Rockefeller Inst. Med. Research, Oct. 10, 1–75, 1921; Public Health Eng. Absts., March 18, 1922. From Chem. Abst., **16:** 1476, May 10, 1922. Pollution of soil and ground water by various types of privies discussed. Under extreme conditions pollution in soil may penetrate to a depth of 10 feet. —*R. E. Thompson.*

Some Factors Affecting the H-ion Concentration of Soil and its Relation to Plant Distribution. W. R. G. Atkins. Sci. Proc. Royal Dublin Soc., **16:** 369–413, 1922. From Chem. Abst., **16:** 1477–8, May 10, 1922. Reactions of natural waters are important in connection with plant distribution. Source of acid seems to be entirely carbon dioxide, and of alkaline reaction chiefly calcium carbonate. Diethyl red was found to be very useful for determination of reactions in vicinity of pH 6.0.—*R. E. Thompson.*

Genelite: An Improved Bearing Alloy. E. G. Gilson. Gen. Elec. Rev., **24:** 949–51, 1922. From Chem. Abst., **16:** 1384, May 10, 1922. Genelite, a synthetic bronze bearing alloy containing 40 per cent finely divided graphite, never seizes and will operate without damage even though the oil supply is shut off for a considerable length of time. It may be used as a self-lubricating bearing.—*R. E. Thompson.*

Unlike Interpretations of Fuller's Scale in Determining Degree of Acidity H. R. Rosen. Science, **55**: 76–7, 1922. From Chem. Abst., **16**: 1444, May 10, 1922. Fuller's Scale indicates the number of cubic centimeters of normal acid or alkali required to render 1 liter of solution neutral to phenolphthalein. The report of the committee of bacteriologists of the American Public Health Association, recommends that acidity and alkalinity be noted in parts per 100. Both yield solutions of practically the same acidity.—*R. E. Thompson.*

Viability of the Colon-Typhoid Group in Carbonated Water and Carbonated Beverages. S. A. Koser and W. W. Skinner. J. Bact., **7**: 111–21, 1922. From Chem. Abst., **16**: 1446, May 10, 1922. Results of an investigation of viability of colon-typhoid group in carbonated beverages are reported.—*R. E. Thompson.*

Titanium, Barium, Strontium and Lithium in Certain Plants. W. P. Headden. Colorado Agr. Expt. Sta. Bull. 267, 20 pp., 1921. From Chem. Abst., **16**: 1447, May 10, 1922. Occurrence of strontium and lithium in groundwaters is reported.—*R. E. Thompson.*

Industrial Gases and Their Containers. E. O. Benjamin. Chem. Age, (N. Y.), **30**: 91–4, 1922. From Chem. Abst., **16**: 1472, May 10, 1922.—*R. E. Thompson.*

First Report of the Gas-Cylinders Research Committee. Anon. J. Soc. Chem. Ind., **41**: 37R, 1922. From Chem. Abst., **16**: 1473, May 10, 1922. Findings of the committee on manufacture and testing of cylinders for storing "permanent" gases are given.—*R. E. Thompson.*

The Metropolitan Water Board and Its Headquarters. Hugh B. Philpott. Water & Water Eng. (London), **24**: 281, August, 1922. Description of new offices on Rosebery Avenue, Clerkenwell, near New River filters. Water Board supplies population within a radius of 560 square miles with an average of 40 gallons of water per day, amounting to 275,000,000 gallons per 24 hours. New storage reservoir at Littleton, near Staines, will have capacity of about 6,500,000,000 gallons.—*Geo. C. Bunker.*

The Artesian Wells and Strata of London. R. Langton Cole. Power User, June, 1922, p. 97. Abstract in Water & Water Eng. (London), **24**: 307, August, 1922. The London artesian basin is 30 by 20 miles in extent, extending from St. Albans in the north to Dorking in the south. Composed of chalk from 500 to 600 feet thick under London and about 800 feet thick at the outcrop. Besides the geology of the section, interesting information is given on wells in this area. Water level is falling. It is predicted that in 30 to 50 years there will be little or no well water available in London. Some interesting facts are given concerning water rates of Metropolitan Water Board.—*Geo. C. Bunker.*

Do Polluted Streams Purify Themselves? J. K. Hoskins. Fire & Water Eng., **72**: 357, August 23, 1922. Observations on studies in natural purification in Illinois River conducted by U. S. Public Health Service. Illus.—*Geo. C. Bunker.*

Relative Cost of Pipe Joints. Fire & Water Eng., **72**: 330, August 16, 1922. Excerpt from report of Committee on Modernization of Stationary Boiler Plants, Mechanical Division, American Railway Association, at annual convention in Atlantic City. Diagram shows cost of fitting pipes in railroad-shop power plants, with flange fittings, screw fittings and welded joints, based on cost per joint, which includes cutting two threads, fitting two flanges and bolts in the case of the flange fittings, or screwing and coupling in case of the screwed fittings. For sizes under 3½ inches, the cost per joint for welded pipe is a little more than the cost of screwed fittings until the smaller sizes are reached, where the two costs run about equal. For sizes 3½ inches and larger, welded joints effect a material saving. In comparison with flanged fittings the saving is considerable for all sizes, averaging close to 50 per cent in the 1 to 6 inch sizes. The saving is not all in the first cost of the fittings, for, by eliminating threaded joints, much longer life and less maintenance may be expected. The weakest point of a threaded pipe is at the threads as far as length of life is concerned. For smaller size pipes, 6-inch and under, where pressures are under 150 pounds the possibility of saving by the use of welded instead of flanged or screwed joints is great. Illustrated.—*Geo. C. Bunker.*

What is Fair Return to Water Companies. Waldo S. Coulter. Fire & Water Eng., **72**: 399, August 30, 1922. Adequate return on investment for the private water company. Points brought out are: (1) Payments for operating expenses and depreciation represent no net income to a water utility; (2) The owner of a water utility should receive substantially more than 5½ per cent on the investment; a utility is entitled to a payment for service; (3) Should consumers pay increased water rates to finance extensions; and (4) The utility is entitled to some return over and above that which it could secure without difficulty, merely by buying conservative bonds.—*Geo. C. Bunker.*

Finding the Comparative Efficiencies of Steam Engines. Power, **56**: 285, August 22, 1922. Illustrated.—*Geo. C. Bunker.*

Watch Out for Static Electricity in Gasoline. Walter L. Wedger. Fire & Water Eng., **72**: 355, August 23, 1922. While this article is not strictly in the water works field it should be read by all superintendents who operate motor vehicles. Describes fires caused by generation of static electricity during handling of gasoline, i.e., in drawing gasoline from a pump into a can or in filling tank of motor vehicle. Generation of static electricity has been noticed when following substances have come together: Gasoline passing through rubber-lined hose; through chamois skin; gasoline being drawn in a forceful stream from a gasoline pump into a metal receptacle which is hung or rests on an insulating substance which prevents the escape of current as generated; gasoline being drawn from a large above-ground tank through a canvas pipe coated inside with shellac varnish.—*Geo. C. Bunker.*

Constructing the New Covered Reservoir at Perth Amboy, New Jersey. ALEXANDER JOHNSON. Contractors' and Engineers' Monthly, **5**: 43, August, 1922. Dimensions: length, 900 feet; width, 230 to 370 feet; water depth, 25 feet. Capacity, 40,000,000 gallons. Cost, $1,095,556.00. The roof and floor are flat-slab reinforced concrete construction, the roof being carried on reinforced concrete columns. Embankment slopes within reservoir are lined with plain concrete. Roof slab is covered with earth to a depth of 2¼ feet. Air vents in the roof project through earth cover and vitrified pipe underdrains are laid in latter. In floor and roof slabs the Smulski system of reinforcement, consisting of rings and radials, was used. Three expansion joints separate floor and roof into four parts of about equal lengths. Panels are 18.5 feet square, except at wall, where span is shortened to about 16 feet. Roof slab is freely supported at wall. Wooden forms were used for walls and steel for columns. Roof forms, also of wood, were constructed in sections 25 feet high and 18.5 feet square, side panels and heads being hinged in order to pass the form between columns when moving ahead. Before pouring slab, the form was wedged into position, and when ready to move ahead, the wedges were drawn and the section advanced by means of timber dollies under each corner. As many as 20 of these forms were moved ahead in one day by 8 men. Illustrated.—*Geo. C. Bunker.*

Sewer Pipe Investigation. Concrete, **21**: 51, August, 1922. Bureau of Standards has undertaken investigation of condition of sewer pipes in city of Los Angeles, for the purpose of studying effect of sewage and sewer gases on clay and cement pipes, both of which are now being extensively used in that city. Investigation involves excavation and inspection of sections of pipe from laterals in various parts of the city, and replacement of these with tested pipe for future examination. The major part of the work, however, consists in the installation of small sections of pipe in manholes in such manner that a part of the specimens will be submerged in the sewage and a part exposed only to the action of the sewer gases.—*Geo. C. Bunker.*

Leather Belting Specifications. Power, **56**: 340, August 29, 1922. Specifications for use as basis of purchase for miscellaneous sizes, single and double ply, of first quality vegetable tanned (so-called oak tanned), leather belting for general use; also waterproof-dressed and waterproof leather belting. Abstract of leaflet prepared by collaborator of the Bureau of Standards for Government purchasing.—*Geo. C. Bunker.*

Some Typical Uses and Properties of "Monel" Metal. EDWIN S. WHEELER AND ROBERT J. MCKAY. Proc. Eng. Soc. of Western Penna., **37**: 311, July, 1921. Discussion of occurrence and metallurgy; typical properties in comparison with some of the generally known metals; principal types of uses and related properties; special uses and related properties.—*Geo. C. Bunker.*

The Oil Engine of Today. CHARLES E. LUCKE. Power, **56**: 241, August 15, 1922. Improvements in general design that have made the oil engine more reliable. Illustrated.—*Geo. C. Bunker.*

Transformation of the Indicator Diagram into the T-N Diagram. Power, 56: 244, August 15, 1922. While the indicator diagram is useful in revealing defects in valve setting, etc., it is of little service if the action of the steam in the cylinder is to be studied. For this reason the P-V diagram, so-called since the vertical ordinate represents pressure while the horizontal ordinate measures piston stroke or piston stroke volume, can be advantageously transformed to the T-N or temperature entropy chart, where the vertical line represents the temperatures and the area inclosed by the admission, expansion, exhaust and compression lines measures the heat of the steam converted into work. Illustrated.—*Geo. C. Bunker.*

Yarway Involute Spray Nozzle. Power, 56: 319, August 29, 1922. Spray nozzle having no internal parts, vanes or deflecting plates. The water in passing through the spray chamber of the nozzle travels in an involute path toward the circular orifice, which is located exactly at the center of the involute. Receiving the water at constant velocity on all sides, the orifice discharges it in a finely divided conical spray. Nozzle has been tried for one year at plant of Dixie Portland Cement Co., Richard City, Tenn. Tests to determine the degree of cooling obtained with nozzles have been made at Johns Hopkins University. Nozzles are handled by the Yarnall-Waring Company, Chestnut Hill, Philadelphia. Illustrated.—*Geo. C. Bunker.*

The Efficiency of Unaflow Engines. A. D. Skinner. Power, 56: 327, August 29, 1922. Points of design that determine the results to be obtained from these engines. Variations in economy due to: auxiliary exhaust valves; hot cylinder heads; leaky steam valves; and steam flow through the valves. Illustrated.—*Geo. C. Bunker.*

Atomizing Cylinder Lubricating Oil. W. F. Osborne. Power, 56: 202, August 8, 1922. Factors that influence size of drops are mechanical means available for atomization, steam velocities, moisture in the steam, temperature, and physical properties of the oil. Illustrated.—*Geo. C. Bunker.*

What Determines the Size of the Oil Drop. W. F. Osborne. Power, 56: 251, August 15, 1922. Aside from the viscosity at the steam temperature and the surface tension, compounding and filtration have some influence upon atomization.—*Geo. C. Bunker.*

Why Cylinder Oil is Compounded. W. F. Osborne. Power, 56: 314, August 29, 1922. When the moisture in the steam reaching the engine cylinder amounts to one-half of 1 per cent or more, a straight mineral oil will not stand up properly, and it is necessary to add some material that will emulsify with the water, the emulsion being used as a lubricant to a certain extent. General practice is to use tallow oil, raw degras or prepared degras for compounding with mineral oil to take care of such a condition. Sometimes lard oil has been used, but it does not seem to be as satisfactory as tallow oil or prepared degras. The normal amount of compounding is about 5 or 6 per cent and where the amount of water is small it can be reduced to 3 or 4 per cent.—*Geo. C. Bunker.*

Care of Valves on Diesel Engines. Louis R. Ford. Power, **56**: 204, August 8, 1922. Maintenance of Diesel engine in good operating condition calls for careful supervision of cylinder-head valves. These valves operate under most difficult conditions found in any kind of service; are subject to high pressure, intense heat and action of corrosive agents in the fuel and the gases resulting from its combustion. Illustrated.—*Geo. C. Bunker.*

The Insulation of Furnace Walls. H. T. Matthew. Power, **56**: 209, August 8, 1922. Energy wasted by loss of heat through ordinary furnace walls ranges from 3 to 15 per cent of heat in the coal. The latter figure, however, is well beyond the limits of ordinary practice, applying only to small boilers operating at extremely low ratings. The other extreme of 3 per cent occurs only with largest boilers operating at high ratings. For average boiler under average operating conditions, this loss is at least 4 per cent. About 0.7 of this amount may, on the average, be saved by proper insulation of furnace walls. This increases boiler over-all efficiency about 3 per cent, but coal saving is greater than that. For example, suppose the boiler efficiency is increased from 60 to 63 per cent by proper insulation of the furnace walls. Then $\frac{3}{63}$, or nearly 5 per cent of coal is saved. With small boilers, operating at low ratings, the percentage of coal saved may be considerably more than this. Data on insulating brick given. Illustrated.—*Geo. C. Bunker.*

New Water System at Brainerd, Minn. G. M. Shepard. Mun. Cty. Engr., **63**: 214–6, 1922. An elevated concrete tank (300,000 gallons) was built on a concrete tower 90 feet high at a cost of $28,574.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

The Use of Filter Rewash. J. H. Suggs. N. C. Sect. Am. W. W. Assn., 1922. Pub. Works, **54**: 22–3, 1923. If improperly used, does more harm than good.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Strange Street Pumping Station, Kitchener, Ont. Marcel Pequegnat. Can. Engr., **44**: 159–62, 1923. A well supply pumped by air lift into a pump well from which it is pumped by two electrically driven centrifugals, (1 at 1 m.g.d., 1 at 1.5 m.g.d.). A reserve pump (1.5 m.g.d.) is connected to a gasoline engine. On air compressor unit, an auxiliary gasoline engine is provided.—*Langdon Pearse.*

Mechanical Equipment of Water Works System. George R. Collinson. Mun. and County Engr., 1922. Can. Engr., **44**: 169–72, 1923. English practice. —*Langdon Pearse.*

Germicidal Effect of Acid Mine Drainage. W. L. Stevenson. Penn. W. W. Assn., 1922. Pub. Works, **53**: 264–5, 1922. Investigation of Lackawanna and Susquehanna Rivers shows that acid mine drainage reduces bacterial content more than 99 per cent and prevents offensive decomposition of sewage reaching the river; both laboratory and field investigations described.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Water Supply and Sewage Disposal Around Lakes. LANGDON PEARSE. Am. P. H. Assn., 1922. Can. Engr., **44**: 150–2, 1923.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Chlorination of Water. SIR ALEXANDER HOUSTON. Can. Engr., **44**: 154–5, 1923. Use of Cl on London water supply has been very successful, followed by permanganate of potash in some cases, or SO_2. Cl varied from 1 in 2.5 to 1 in 4.0 mil. Imp. Gal.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Cost of Filtering and Pumping Water at Providence, R. I. M. H. BRONSDEN. Ann. Report, 1921. Eng. Contrg., **59**: 124, 1923. Costs are given year by year from 1907 to 1921 inclusive, for pumping, cleaning beds, etc.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

Relation of Water Company and Consumer. EUGENE CARROLL. Eng. Contrg., **59**: 77–9, 1923. Methods of encouraging friendly relations.—*Langdon Pearse.* (*Courtesy Chem. Abst.*)

The Design of Masonry Dams. EDWARD WEGMANN. Int. Eng. Congress, Brazil, 1922. Eng. Contrg., **58**: 121–7, 1922; **59**: 81–8, 1923. Thorough outline of historical examples and evolution of theory of design.—*Langdon Pearse.*

Methods of Measuring Depth of Water in Deep Well. J. G. THORNE. Eng. Contrg., **59**: 88, 1923. Mun. Cty. Eng., **63**: 240, 1923. Electrical method.—*Langdon Pearse.*

Economic Aspect of Water Works Management. V. B. SIEMS. Four States Sect., Am. W. W. Assn., 1922. Eng. Contrg., **59**: 89–92, 1923. Mun. Cty. Eng., **53**: 229–32, 1923. Advantages of putting municipally owned water plants on business basis, covering rates, how determined. Plant should be self supporting.—*Langdon Pearse.*

An Investigation of Herschel Type of Weir. R. H. MORRIS AND A. J. R. HOUSTON. Eng. Contrg. **59**: 93–8, 1923. Test on a new form of weir with a rounded crest, discharging about 20 per cent more water than ordinary measuring types.—*Langdon Pearse.*

Loss of Head in Sudden Enlargements in Circular Pipes. F. W. MEDAUGH. Eng. Contrg., **59**: 79–80, 1923. General discussion.—*Langdon Pearse.*

Loss of Head in Bends of Less than 90 Degrees. F. W. MEDAUGH. Eng. Contrg., **58**: 118, 1922.—*Langdon Pearse.*

Use of Labor Saving Equipment at New Bedford, Mass., in Laying 48-inch Main. S. H. TAYLOR. Eng. Contrg., **58**: 119–20, 1922. Use of a self-propelled steam shovel with extended dipper arm for trenching was helpful. Leadite was used in joints. Details of cost are given.—*Langdon Pearse.*

Methods and Costs of Myers-Whaley Shovel Operations in Waterworks Tunnels. Eng. Contrg., **58**: 132–6, 1922. Use of machines in mucking in tunnels is described, in particular on Hetch Hetchy and Shandaken tunnels. Number of men and cost of mucking are materially reduced.—*Langdon Pearse.*

Design and Construction of a Rectangular Suspended Gunite Flume. W. A. Kunigk. Eng. Contrg., **59**: 100–4, 1923. This flume was 5 feet wide by 4 feet 3 inches deep where carried on a bridge. The gunite was shot 3 inches thick against an outer form in freezing weather under canvas. Expansion joints of copper are provided at ends. Costs are given in detail, totaling $20.15 per linear foot flume. The gunite crew with a payroll of $62.75 per 8-hour day placed on average 5.31 cubic yards per day, with maximum of 7. Gunite cost for material $15.68, for labor $11.81 or $27.49 per cubic yard.—*Langdon Pearse.*

Different Properties of Microbic Growths, Dry or Liquid. A. Trillat. Comptes rend., **176**: 144–146, 1923. Journ. Soc. Chem. Ind., **42**: 199a, March 9, 1923. Microbic droplets of Prodigiosus can, under a feeble pressure, traverse a plug of cotton-wool, weighing 2–4 g. and 10 cm. long, and in a test with a guinea-pig it was shown that, by inhalation for 5 minutes of air charged with the organism, the latter penetrates in less than a minute into the deepest parts of the lungs of the animal. With dry growth, mixed with talc powder, it is different. Even after inhalation for 15 minutes a positive result could not be obtained.—(W. G.)—*A. M. Buswell.*

Determination of Hardness of Industrial Water. F. Kanhauser. Chem-Zeit., **47**: 57–59, 1923. Journ. Soc. Chem. Ind., **42**: 198a, Mar. 9, 1923. Influence of the presence of organic matter on the determination of hardness was investigated. Winkler's modification of Blacher's potassium palmitate method (J., 1913, 158; 1914, 709), described in detail, was found to give trustworthy results with all kinds of industrial waters on which it was tried. No correction applied to volume of palmitate used. Presence of iron and manganese does not affect the accuracy of results. Considerable quantities of organic matter (phenols, fatty and mineral oils, etc.), accumulate in boiler waters, and may influence surface tension to such an extent that Clark's soap method for determining hardness becomes useless, as the waters already foam before any soap is added. Organic matter also disturbs other methods, depending on titration with methyl orange as indicator, in that it is usually acid. Organic acids not being volatile, cannot be removed by aeration like carbonic acid. Water must therefore first be titrated until neutral to methyl orange and then until neutral to phenolphthalein, as in Blacher's method. Examples are given of serious errors introduced by neglecting to allow for organic acids. If water is not sufficiently decolorized by addition of a few drops of bromine water to allow of titrations being carried out, it must be evaporated to dryness with a few drops of aqua regia, the residue dissolved in distilled water, and the hardness of this solution determined. Details are given of an adaptation of Blacher's method to the volumetric determinations of sulphates. It is considered that the organic acids accumulating in boiler water have an important influence on corrosion.—(H. C. R.)—*A. M. Buswell.*

Accumulation of Salts in Streams in Regard to Water Supply. Pfeiffer Gas-u. Wasserfach, **66**: 17–20, 1923. Journ. Soc. Chem. Ind., **42**: 198a, Mar. 9, 1923. Pollution of surface waters by factory effluents and effect of consequent accumulation of salts on processes of purification.—(A. G. P.)—*A. M. Buswell.*

Hypochlorite Solutions and "Antiformin" (Preparation and Properties of). E. O. Rasser. Chem-Zeit., **47**: 37–38, 1923. Journ. Soc. Chem. Ind., **42**: 198a, March 9, 1923. Antiformin, which contains about 5 per cent of available chlorine and 0.35 per cent of caustic soda, may be satisfactorily replaced by cheaper solutions prepared electrolytically. For instance, 30 liters of a solution of sodium hypochlorite containing 3.98 g. of available chlorine per liter, is produced in 1 hour when a 5 per cent solution of salt is electrolysed by means of a current of 8 amps. at 110 volts (1.15 kw.). This may be converted into serviceable and stable disinfectant by diluting it to 60 liters and adding 0.9 kgm. of sodium carbonate. Addition of sodium carbonate to solution of hypochlorite increases its penetrative power and stability. During six weeks, a hypochlorite solution, containing 3.65 per cent of available chlorine and some sodium carbonate lost 0.05 per cent in strength, but under similar conditions a hypochlorite solution containing no sodium carbonate lost 2.56 per cent.—(A. J. H.)—*A. M. Buswell.*

Colorimetric Determinations of Nitrates in Water. B. Lampe. Woch. Brau., **39**: 303–304, 1922. Journ. Soc. Chem. Ind., **42**: 198a, March 9, 1923. The following simple modification of Grandval and Lajoux's method for estimating nitrates in water is not affected by presence of nitrite or organic matter in small proportions usually found in natural water. An Erlenmeyer flask containing 30 cc. of the water is weighed and liquid then boiled with amount of silver sulphate solution necessary to precipitate the chloride present. After being cooled, the flask and its contents are made up to original weight and solution thoroughly mixed. Solution is then filtered through dry filter paper until clear, 25 cc. of filtrate being evaporated to dryness in porcelain dish on water bath and residue mixed by means of flattened glass rod with 15–20 drops of reagent prepared by mixing 0.75 g. of pure phenol with 9.25 g. of pure, concentrated sulphuric acid. The contents of the dish are transferred to a 200 cc. flask, mixed with 10 cc. of 10 per cent ammonia solution, and made up to volume. In presence of nitrate solution is colored yellow owing to formation of ammonium picrate. A solution containing 3.844 g. of potassium nitrate per liter is prepared, 10 cc. of this being diluted to 200 cc. and 25 cc. of the diluted liquid evaporated to dryness, treated with the phenol-sulphuric acid reagent as described above, and made up to 500 cc. after addition of ammonia. For comparing the colorations, use may be made of a series of similar flasks such as are employed for comparing the colors of worts. If a cell 20 mm. thick, containing a solution of 25 g. of copper sulphate in 100 cc. of water, is used as a screen, the accuracy of comparison is increased.—(T. H.P.)—*A. M. Buswell.*

Progress in Water Purification. Sir Alexander C. Houston. Water & Water Engineering, **24**: 445–450, 1922. Definition of "pure and wholesome

water." Slow sand filters are recommended for bacterially unsafe waters; rapid sand filters for epidemiologically safe, colored waters.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Sterilization and Filtration of Water by the "Ferrochlore" Process. NOËL ADAM. Rev. d' Hyg., **12**: 1169–1175, 1922. Process invented in 1902 by Duyk, a Belgian chemist, is based on use of two reagents: calcium hypochlorite and either ferric chloride or iron-bearing aluminum sulphate, depending on which of two latter is cheapest. In experiments reported 0.75 to 4.0 p.p.m. $CaOCl_2$, and 10–20 p.p.m. $FeCl_3$ or 30–40 p.p.m. alum were used.—*Jack J. Hinman, Jr.* (*Courtesy Chem Abst.*)

Installation for the Removal of Iron from the Drinking Water for the City of Greifswald. KROPF. Die Wasserkraft, Sept. 1, 1922, pp. 334–5. Water and Water Engineering, **24**: 457, 1922. Detailed description of apparatus and innovations for reducing clogging and difficulty of cleaning. Water flows through sprinklers in form of pipe bundles, each pipe of which delivers water into a metal saucer from edges of which it falls as a spray.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Inspection of Water Supplies. F. DIENERT. La Technique Sanitaire et Municipale, pp. 188–193, Aug., 1922. Water and Water Eng., **24**: 459, 1922. Underground sources are especially considered, and need of studying geological formations, and rates of flow of water through them, and of applying this knowledge to inspection of supplies, is urged. Frequent determinations of temperature of water indicate possible origin and rate of circulation. Supplies from wooded areas are always colder than those from cultivated ground devoid of trees.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Observations on Typhoid Fever in the Province of Milan. P. L. FIORANI. Giornale delle Reale Societa Italiana d'Igiene, Mar., 1922; L'Igiene Moderna, **15**: 182, 1922; Bul. mens. internat. office d'hyg. publ., **14**: 1437, 1922. Increase in typhoid noted in 1921, an exceptionally dry year. In addition to influence of lowering of the water table in wells (Pettenkoffer theory), Fiorani also blames extraordinary water shortage and use of polluted canal water for washing green vegetables and utensils of kitchen and dairy.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Remarks on the Hottingher Method of Water Sterilization. GUIDO RIGOBELLO. L'Igiene Moderna, **15**: 166, 1922. Bul. mens. office internat d'hyg. pub., 14: 1575, 1922. Based on deposit of silver fixed by means of colloidal solution on the interior of porous earthenware jar, or alcarazas. Sold on claim that water will be safe for drinking after one hour in jar, and that method has been approved by health authorities of Brazil. Fiorani found action limited and not capable of guaranteeing freedom from all infection, but of some value from simplicity and economy for use in remote places.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Drinking Water for Animals. L. PAUTET. L'Eau, p. 7, July 15, 1922. Water and Water Eng., **24**: 413, Nov. 20, 1922. Necessity of pure water at right temperature. Recommends 12–14°C. in winter and 15–18°C. in summer.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Plumbing Regulations. GEO. C. WHIPPLE. Public Health, Mich. St. Bd. Health, **11**: 25–29, 1923. Recommends revision of plumbing regulations to conform to modern scientific knowledge. Discusses present state of "sewer gas" question.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Typhoid Fever. FRANK G. BOUDREAU. Public Health, Mich. St. Bd. Health, **11**: 4–16, 1923. On the disease and its prevention, with emphasis on milk and water borne epidemics. Water borne typhoid is proportionally much less important than it was 20 or 30 years ago, the other methods of distribution being now the more common. The Salem, Ohio, epidemic is reported in detail. Epidemics at Circleville, Van Wert, and Xenia (2), Ohio, are given as examples of epidemics due to cross connections to polluted private supplies. One at Xenia is given as due to loss of strength of calcium hypochlorite, and one at Alliance as due to insufficient and inferior chemicals used on the water supply. Water borne epidemics are characterized by: (1) Slow increase and decline in number of cases throughout epidemic except where pollution of a satisfactory supply with a sudden load of polluting material occurred. (A small continuous pollution may also give an endemic character to the disease.) (2) Usually preceded by an outbreak of enteritis and diarrhea. (3) Almost always in the winter and the spring. (4) Source is usually nearby as organisms do not live long in water. (5) Cases are generally distributed in accordance with density of population, though in some cases they vary inversely as the distance from the plant. (6) Other possible sources must be eliminated, as the evidence against the water is usually circumstantial particularly in case of a water supply that is not examined often enough to know its variation with conditions. At the time of the outbreak the supply may have returned to good bacteriological quality, though previously very dangerous pollution was present.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Summary of Installations of Public Water Supplies in Austria. A. SWETZ. Mitt. d. Volksgesundheitsamts, Nov. 1, 1922; Bull. mens. office internat. d'hyg. publ., **15**: 141, Jan., 1923. General survey. Springs most frequently used as sources of supply, though subterranean waters are used in river valleys of the Danube, Viener-Neustadt in Lower Austria, Lintz and Urfahr in Upper Austria. Natural gravity distribution mostly used. Very few purification plants, as watersheds are protected. Plants are usually owned by communities or by associations of consumers.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Swimming Pool Conjunctivitis. F. BEST. Münchener med. Wochenschrift, **69**: 621, 1922. Bull. mens. office internat. d'hyg. publ., **15**: 129, 1923. Swimming pool conjunctivitis described by Fehr in 1900, and observed by Pader-

stein and Comberg at Berlin since 1912. Best has seen a number of cases at Dresden, and notes: (1) Characteristic symptom, follicles with swelling and redness at first appearing like trachoma. Follicles rapidly disappear, sometimes before 15 days. (2) Follicles are about as numerous in upper as in lower lid, and may be in but one eye. (3) In several cases the cornea was affected. (4) The maximum course was 6 months and no scars were left. (5) Coryza is a frequent accompaniment. Nearly all cases were in men. Chlorination of the pool water is advised.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Potable Water Supplies of the Cities of the Ruhr. "L.D." L'Eau, **16**: 17, Feb. 15, 1923. Historical development of supplies of region together with a map showing location of plants, reservoirs, etc.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

On the Purification of Drinking Water for Troops in the Field. ANTONIO ANGELINI. Giornale di Medicina militaire, **71**: 22, Jan., 1923. Bull mens. internat. office d'hyg. publ., **15**: 409, Mar., 1923. In the Italian army germicides used in water purification were found to have power on water saprophytes in decreasing order as follows: sodium hypochlorite, "Idrosan," tincture of iodine, $KMnO_4$ and powders based on permanganates.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Action of Chlorinated Water on Galvanized Iron Tanks. N. V. LOTHIAN AND A. R. WARD. J. Roy. Army Medical Corps, Sept., 1922. J. Soc. Chem. Ind., **42**: 68A, Jan. 26, 1923. While natural waters took up zinc, especially from new tanks, chlorinated waters took up more. Average 1.4 grains per Imp. Gal. in 24 hours; 2.1 in 2 days; 3.5 in 3 days, and smaller increases subsequently. Toxicity is doubtful. Water containing 0.5 grain Zn was used for months in France without effect.—*Jack Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Economy of High Initial Cost and Extreme Care in Service-Pipe Installations. REEVES J. NEWSON. Jour. N. E. W. W. Assoc., **36**: 1, 79, Mar., 1922. In Lynn, Mass., cost of cleaning service pipe averages about $2 per service every 5 years and cleaning is preceded by periods when service pipe is unsatisfactory. Somewhat larger investment and greater care in original installation is economical and good policy in the matter of reducing complaints. At Lynn 1¼-inch cement lined wrought iron service pipe is used for ordinary installations. A special cone is used for shaping the cement and gives concentric lining. Great care is required at connections. Corporation cocks are provided with ¾ inch extension into the main, so rust will not obstruct entrance. Fittings are lead lined and all joints are made to give tight fit. Pipe is cut in shop to careful measurements made for each individual job. Average additional cost for this type of service pipe is approximately $5.50 each.—*E. S. Chase.*

Monel Metal and Its Suitability for Water Works Use. H. S. Arnold. Jour. N. E. W. W. Assoc., 36: 1, 86, Mar., 1922. Brief description of source of ore and method of refining. Monel metal is an alloy containing approximately 67 per cent nickel, 28 per cent copper and 5 per cent other metals chiefly iron, manganese and silicon. Its physical properties resemble those of mild steel and combine strength with resistance to corrosion and to high temperature. It can be cast, forged, hot rolled, or cold drawn; and may be welded, brazed, soldered, stamped, machined, and polished. Its properties render it valuable for use with superheated and wet steam and hot water. It has given good service in valve seats and other valve parts subject to wear. In the water works field it is employed for gear parts in water meters, in pumps, in hydrants, valve stems, filter screens, etc.—*E. S. Chase.*

The Chlorination of New England Water Supplies. Wm. J. Orchard Jour. N. E. W. W. Assoc., 36: 1, 99, Mar., 1922. Discussion of relatively small part chlorination plays in sanitary protection of New England water supplies in spite of fact that pioneer work in this form of water treatment was done in New England and by New Englanders.—*E. S. Chase.*

Reinforced Concrete Pipe as Applied to Water-Supply Lines. W. G. Chace. Jour. N. E. W. W. Assoc., 36: 1, 102, Mar., 1922. Design and construction of reinforced concrete pipe with details as to construction of joints for water tightness. It is claimed that concrete pipe lines with properly made joints show little leakage and on account of smoothness of the interior have low friction losses. In the 97 miles of the Winnepeg concrete conduit there was an estimated loss of but 0.5 per cent of water from leakage. In constructing pipe, water tightness of concrete may be obtained with little loss of strength by introducing a small amount of colloidal material into the mix. With heads up to 100 feet, mesh and cage or bar reinforcement is satisfactory, for higher heads a cylindrical water stop of thin sheet steel is used.—*E. S. Chase.*

Steam Boilers. F. W. Dean. Jour. N. E. W. W. Assoc., 36: 1, 115, Mar., 1922. Different types of boilers and various points to be considered in their design and operation. In connection with water tube boilers, baffles, methods of closing holes in hand-hole plates, circulation, steel casings, drum heads, steam pressure, size of tubes, method of taking steam and boring of tubes are discussed. In connection with horizontal return tubular boilers, riveted joints, methods of support, size of tubes, height of boiler above floor, and height of bridge walls, are considered. In discussion of boilers, forcing capacity, high pressure, reduction of pressure from age, safety, rivet heads, water gages, feed water regulators, superheaters, soot blowers, temperature of flue gases, mechanical stokers, pulverized coal, hand stokers, oil fuel, grate bars and feeding of boilers are covered. Concludes with notes on results of tests of emergency fleet boiler for wood ships.—*E. S. Chase.*

Water Laws of Alabama. Bureau of Engineering, State Board of Health, (pamphlet form). The State Board of Health of Alabama has general supervision and control over all water supplies and water works in the state, in

so far as sanitary and physical quality affects public health. Samples shall be examined every 3 months or oftener by State Board of Health and it is unlawful to furnish impure water. Plans for prospective water works systems must be filed with State Health Board. Investigations of proposed or existing works are made by the Board at the expense of the water corporation. The Board has power to forbid the use of impure supplies and issues permits for good supplies. Appeal from orders of the Board may be made to courts. Penalty provided of not more than $1000 for each violation of water laws.—*E. S. Chase.*

Annual Report of the State Board of Health of Alabama. Two Years ending Dec. 31, 1920, (published 1922). Report of the Bureau of Sanitary Engineering for 1919, page 77, 1920, page 191. Abstracts of various water supply investigations made during the two years. Interesting example of well pollution by flood waters described as occurring at Montgomery (p. 87).—*E. S. Chase.*

Annual Report of the State Board of Health of Georgia for 1921. Report of the Division of Sanitary Engineering (p. 18) gives outline of work of division, including water supply investigations and analyses. 250 municipal water supplies in Georgia are from deep wells, springs and streams. 75 per cent of the spring supplies are chlorinated and all the surface supplies are subjected to purification.—*E. S. Chase.*

Annual Report of the State Board of Health of Montana for 1919–20. Report of the Division of Water Supply and Sewage outlines the work carried out in connection with supervision and control of public water supplies. Montana has 112 public water supplies, about 60 per cent of which have been placed in the approved list. In 1910, Montana had a typhoid fever death rate of 39.9 per 100,000 population, which has dropped to 8.2 in 1919; this drop being attributed to improvements in public water supplies. Board has two emergancy chlorination plants.—*E. S. Chase.*

Annual Report of the State Board of Health of South Carolina for 1921. Report of the State Sanitary Engineer (p. 113) describes work on water supply investigations. Over one-half the public water supplies in the state taken from surface sources are chlorinated.—*E. S. Chase.*

Sanitary Code of South Carolina. State Board of Health, 1919, p. 53, S 404. Water analyses are required for public water supplies not less than once every three months and results shall be published. If inspection made by State Board of Health discloses conditions dangerous to health, the Board shall notify the municipal officials and demand immediate abatement. If order is not complied with in 30 days, a statement of the facts shall be published in one, or more, local newspapers. Penalty of fine not exceeding $100 or imprisonment not exceeding 30 days is provided for failure to comply with provisions of the law.—*E. S. Chase.*

Public Water Filtration and Chlorination. F. E. Daniels. Penn. State Dept. Health, Bull. 107, **57**: Feb., 1922. Outline of water purification processes. In Pittsburgh engineering district there is a yearly economic loss of \$20,000,000 due to hard and acid mine waters.—*E. S. Chase.*

Progress Report of the Committee on Rainfall and Run-off. Kenneth Allen, Chairman. Municipal Engineers Jour., (New York), 1st Quart. Issue, **8**: 22. Refers to the previous report of 1913. A list of rain gages from which records have been obtained for the New York Metropolitan District is given. Data are tabulated for a series of heavy storms in 1913, together with maximum intensities of rainfall for short periods of time. A plate is given showing maximum rainfall intensity curves proposed for New York City. Tables are also given of observed per cent run-off for certain severe storms from certain areas.—*E. S. Chase.*

Corrosion of Iron and Steel in Natural Waters. The Mechanism of and Calculation of Specific Rates. Robt. E. Wilson. Jour. Ind. & Eng. Chem., **15**: 127, Feb., 1923. Regardless to what school of corrosion theory personal allegiance is given the fundamental reaction in corrosion of iron is essentially

$$\underset{\text{(metal)}}{Fe} + \underset{\text{(acid ion)}}{2\,H^+} \rightarrow \underset{\text{(soluble ion)}}{Fe^{++}} + \underset{\text{(nascent gas)}}{2\,H} \tag{1}$$

The film of hydrogen must be disposed of by one of the reactions

$$\underset{\text{(nascent gas)}}{2\,H} + \underset{\text{(dissolved oxygen)}}{(\tfrac{1}{2}\,O_2)} \rightarrow \underset{\text{(water)}}{H_2O} \tag{2}$$

$$\text{or} \quad \underset{\text{(nascent gas)}}{2\,H} \rightarrow \underset{\text{(free molecular hydrogen gas)}}{H_2} \tag{3}$$

Reactions (1) and (2) practically always determine the rate of corrosion in natural waters such being controlled by whichever is inherently slower. Proof is given to show reaction (2) to be controlling *regardless of the hydrogen ion concentration within ordinary limits* in natural waters. Verification is shown through experiments where the concentration of H ions had to be decreased to a value of pH 10, or higher, before the added alkali began to exert an appreciable retarding of the rate of corrosion. At alkalinities lower than pH 11, corresponding to those in natural waters, the potential rate of reaction (1) becomes so high that the rate of corrosion is limited *only by the oxygen content.* (Data in curve form shows for range of pH 11.5 to pH 5 flat lines for rates of corrosion the positions of which are governed by the oxygen content alone. Below pH 4, however, the rate of corrosion rapidly increases and above pH 11.5 it rapidly diminishes *regardless of the oxygen content*). Below pH 5 the phenomena of hydrogen-over-voltage becomes the most important factor in rates of corrosion. In pipe experiments the rate of diffusion

of the oxygen plays the most important rôle. Low velocities of flow (straight line flow) give very low rates of corrosion as compared with those obtained during turbulent flow (high velocities) and consequent greater contact of the dissolved oxygen with the hydrogen film on the metal and accelerating reaction (2) thereby. Inevitable conclusions are that presence of impurities, the composition of and heat treatment of iron or steel should not appreciably affect results. Previous experimental data have undoubtedly been affected through failure to take into consideration the amount of circulation of liquids in contact with the metals. Observed decrease in rate of corrosion with *increased alkalinity* is due solely to changes in the *rate* at which H^+, produced by ionization of the water, can react with the metal, and *not* to any inherent equilibrium which prevents the progress of corrosion action. Between pH 11.5 and 13, *temperature* should have a marked effect in accelerating the rate of corrosion due to increasing ionization of water; but rate of circulation, rust films, presence of other salts, hydrogen overvoltage, purity of metal, etc. should have very little, if any, effect. In moderately acid solutions (pH 4 or less) the most important factor governing corrosion is the hydrogen-overvoltage of the metal and impurities present. Under such conditions pressure accelerates and vacuum retards corrosion while anything tending to decrease the average bubble size of the hydrogen gas evolution, such as moderate stirring, *retards* corrosion. Absorbed materials such as arsenic and formaldehyde when present also retard corrosion. The oxygen content, salt content, solution-pressure of metal, etc. should have comparatively little effect on corrosion rates in acids. To summarize: the whole field of corrosion of iron by dilute aqueous solutions may be divided into three main regions of *varying* hydrogen-ion concentration, in each of which a different but comparatively simple reaction controls the rate of corrosion. (Data in curve form show reaction (1) controls in range pH 10.5 to 13.0 where the hydrogen ion controls. Reaction (2) controls in range pH 10.5 to 4.5 where dissolved oxygen controls. Reaction (3) controls in range pH 4.5 to 2.0 where liberation of molecular hydrogen gas controls). Where two dissimilar metals are in contact their relative hydrogen voltage will govern the rate of corrosion and be the determining factor as to which metal will corrode due to the flow of galvanic currents. "In all cases of two metals in contact, as the acid concentration is increased, corrosion will pass from the region where the rate of diffusion of oxygen is controlling to the region where the rate of evolution of hydrogen, as determined primarily by overvoltage phenomena, becomes determining." It is recommended that all data on corrosion be expressed as "Specific Rate of Corrosion" (K) = *milligrams loss per square centimeter per year per cubic centimeter of oxygen in 1 liter of water*. In cases where the rate of corrosion is being measured on long pipes the average oxygen content should not be taken from arithmetic mean of initial and final value. For such cases the "logarithmetric mean" is correct. Formulae are given to illustrate such calculations. Other things being equal the specific rate of corrosion (K) is proportional to the log. of the *ratio* of intial to final oxygen content. Summarizing, in order for corrosion data in natural waters to be of value, the composition of the water is *not* important, save for its *oxygen content* and its tendency to form protective films, while the usually neglected factor of *velocity* should be carefully measured and specified.—*Linn H. Enslow.*

Corrosion in Water, A New Method of Measuring. F. N. Speller and V. V. Kendall. Jour. Ind. & Engr. Chem., 15: 134, February, 1923. That corrosion by natural waters is directly proportional to dissolved oxygen content is further proven through experiments confirming previous data and theory. Other main factors are temperature, velocity of flow, composition of the water and protective action of rust-films or other deposits formed on the metal surface. All data from the experiments were calculated to "*specific rate of corrosion*" = (K) = milligram of metal loss per square centimeter per year per cubic centimeter oxygen in 1 liter of water

$$\text{(or)} \qquad K = \frac{4{,}020{,}000 \times \text{liters water per min.} \times \log.\dfrac{\text{initial } O_2{}^{*}}{\text{final } O_2}}{\text{Area of metal surface in sq. cm.}}$$

* Oxygen determined as c.c. per liter of water by the Winkler method as described in Standard Methods of Water Analysis of the A. P. H. A. for dissolved oxygen.

The value K is then plotted against velocities and temperatures from which the following conclusions are drawn. (1) At low velocities (straight-line flow) in pipes at temperatures up to 80°F. corrosion is much less rapid than is the case when velocity enters a critical range approaching turbulent-flow and also in *all* cases of known turbulent flow. Velocities ranged up to and included 8 ft./sec. in ½ inch; 4 ft./sec. in ¼ inch and 3 ft./sec. in ¾ inch steel pipes.

(2) That regardless of velocities corrosion increases in direct proportion to increase in temperature, the rate being remarkably accelerated at temperatures above 120°F.

(3) That specific rate of corrosion decreases with increase in size of pipe, indicating it of advantage to install oversize piping and thereby an increased life of the piping.

(4) That at any given temperature an increase in velocity above that customarily used through deactivators will increase their efficiency in most instances. That the higher the temperature the greater may be the velocity through them. Increased number of plates and baffles produces a desired velocity increase as well as increased metal surface-area for oxygen contact. The method and apparatus employed in the experimental work are clearly described and readily understood, void of "mystic" scientific phrases and complex formulae, and are amply illustrated so as to be readily available to those having a practical corrosion problem to solve. The results are sufficiently conclusive to warrant application to practice in many problems of pipe installation.—*Linn H. Enslow.*

The New Filtration Plant of the Norfolk Water Works. David A. Decker. Amer. City, 28: 25–28, 1923. Description of new works at Norfolk, Va., comprising artificial reservoir of 4 billion gallons to yield 17–18 m.g.d. Pump at dam delivers to filtration plant 18.5 miles distance. Purification consists of aerator, two coagulating basins 2.5 m.g., twelve 1 m.g.d. filters, clear basin 3.0 m.g. Features are (a) aerator of spilling flume type with 7 steps (b)

coagulating basin built over clear well (c) false bottom underdrains and umbrella strainers for filters (d) wash tank approximately 4 x 14 x 101 feet supplied by motor pump (e) automatic alum feed. The H.S. pump station adjoining filter has both motor and steam-driven pumps.—*W. Donaldson.*

New York State to Give Water-Works and Sewage Disposal Course. Anon. Amer. City, **28**: 116, 1923. Outline of course offered by Division of Sanitation, New York State Department of Health, beginning February 5, comprising reading and lectures.—*W. Donaldson.*

Make Your Water-Works Grounds Attractive. R. E. McDonell. Amer. City, **28**: 129–30, 1923. Excerpts from paper before Southwestern Waterworks Association, 1922, advocating more attention to this feature.—*W. Donaldson.*

Dangers to the Sanitary Quality of Public Water Supplies. E. Sherman Chase. Amer. City, **28**: 161–3, 277–9, 1923. Reprint of paper before New England Waterworks Association, 1922, in which author points out potential hazards to surface supplies from agriculture, labor operations, typhoid carriers, boating, and fishing. Hazards due to lax management and accidental interruptions are dealt with, also hazards incidental to ground water supplies. Examples are cited to illustrate points mentioned.—*W. Donaldson.*

Water Supply Contamination by Mine Drainage. J. W. Ledoux. Amer. City, **28**: 264, 1923. Serious damage to water supplies in Pennsylvania caused by acid drainage from coal mines is discussed. Instances of abandonment of water supplies by reason of such pollution. Legal resources of water companies and municipalities in Pennsylvania and other States are open to question.—*W. Donaldson.*

Abridged Report upon Central Water Supply Project for Maritime Flanders Government (of Holland) Water Supply Bureau. (Maritime Flanders is the narrow strip of Dutch territory, about 40 miles long, and nowhere more than 11 miles broad, on left bank of Scheldt estuary.—*Abstr.*) With no considerable towns; population, 83,000, about one-half of whom reckoned upon for connections at outset. Initial supply of 690,000 gallons per day (inclusive of 42,000 gallons for live stock) figured upon. Expected to double within 30 years. Single source of suitable supply located after difficult search; to be drawn from wells in sand. Larger part of territory will derive supply direct from primary pumping station: secondary pumping station needed for westerly area. Carefully drawn estimates of income and expenditure for each year for 30 years given. Government to advance capital upon 6 per cent interest footing. Based upon initial outlay of $2,700,000, and reserve of $250,000, undertaking expected to yield surplus.—*Frank Hannan.*

The Adsorption of Acids by Hydrated Alumina Precipitates. A. Charriou. Compt. Rend., **176**: 679–82, 1923; C. A., **17**: 1930, 1923. When $Al_2(OH)_3$ is precipitated in chromate solution, chromate ion is adsorbed, but may be washed out with cold solution of ammonium bicarbonate. Precipitate is then washed with hot water and calcined for weighing.—*W. D. Hatfield.*

Proposed Extension of the Metropolitan Water District. X. H. Goodnough. Jour. N. E. W.W. Assoc., **36**: 2, 189, June, 1922. Studies of water supply needs and resources of State of Massachusetts with special reference to requirements of certain districts, most important of which is Metropolitan Water District. Proposed to utilize flood flows of streams in Connecticut River watershed, including Ware, Swift, and Millers Rivers, and, eventually, Quaboag, Deerfield, Westfield, and others. By taking only flood flows, serious injury to water powers on rivers below will be avoided. Extension includes construction of large reservoir on Swift River by dam at boundary line between Enfield and Ware, and secondary dam, or dike, in Beaver Brook Valley, about three miles northeast of main dam. Main dam would be 271 ft. high above bottom of rock gorge and 2,700 ft. long at flow line. Beaver Brook dike would be of about the same height and 2,150 ft. long at flow line. Reservoir would have water surface area of 39 square miles and total capacity of 410,000 million gallons. Total area of tributary watershed would be 536 square miles, including areas divertable from Ware and Millers Rivers. Water from this reservoir would be brought to existing Wachusett Reservoir through tunnel in rocks, 12 ft. 9 in. in diameter and about 25 miles long. Tunnel would pass Coldbrook in Ware River Valley and provide for diversion of water of this river directly into one of tunnel shafts. Diversion of Millers River water would be accomplished by tunnel and aqueduct about 11.5 ft. in diameter extending from diversion works just above Athol, to Eagleville Pond on Millers River, and thence, by a channel cut through the divide, into Swift River Reservoir. Total flow of 200 million gallons per day would be obtained by project. Development of water power would be made practicable at several points. Total estimated cost of project is $59,946,540. Estimated cost of tunnel and necessary terminal works from Wachusett Reservoir to Ware River at Coldbrook, which it is proposed to construct first, and which will give an additional safe yield of about 33 million gallons per day, is $12,043,380.—*Almon L. Fales.*

Coöperation of Water Works Operators with the Public and Employees. F. T. Kemble. Jour. N.E.W.W. Assoc., **36**: 3, 363, Sept., 1922. Importance of operators being willing to listen to complaints, reason with them, and explain conditions to them. In case of employees, the need is "heart in the work" and this best secured by sympathetic understanding between heads of force and employees. In the discussion of paper, difficulty in getting reliable new men, particularly young men, as laborers was pointed out. One suggestion was that an attractive old-age or service pension would be best solution of problem. Other suggestions were to have all-the-year-round work for as many of the men as possible, to find work in the yards on rainy days to prevent lost time, and to make the wage sufficiently attractive to get and keep good men.—*Almon L. Fales.*

The New Water Supply of the City of Providence. Frank E. Winsor. Jour. N. E. W. W. Assoc., **36**: 3, 323, Sept., 1922. New supply will be taken from north branch of Pawtuxet River, above practically all sources of pollution, by constructing large storage reservoir at Scituate, where drainage area is 92.8 square miles, which will give safe yield of 85 million gallons per day or

nearly four times present consumption of city. Reservoir will have water surface of 3600 acres, flow line of 38 miles, average depth of 32 ft., and storage capacity of 36,900 million gallons. Total area which city will control is about 15,000 acres,—considerably more than area of city itself. On condemned area are 357 dwellings, 7 school houses, 6 churches, 6 cotton mill plants and 173 cemetery lots. Reservoir area, including a 30-ft. marginal strip, will be cleared of all vegetation before flooding, and stumps and roots will be generally removed from areas submerged less than about 25 ft. Sub-surface investigations, including test pits, rod soundings, wash borings and diamond-drill borings described in detail. Main dam will be about 3200 ft. long and 180 ft. in maximum height above bed rock, cubic contents of dam, including refilling below surface of ground, being about 2,500,000 cubic yards. Designs of dam and dike described, with construction details, and photographs showing progress of work. A masonry core wall considered, but deemed inadvisable on account of very porous character of material available for abutting fill. The possibilities of hydraulic dam construction were considered at great length. It was finally decided to require impervious core wall be placed in thin layers, wet, and rolled with heavy rollers. Percolation tests of materials for core of dam are described at length. Total length of aqueduct from the gate house in dam to present distribution system will be about 7 miles of which 3½ miles is in tunnel. It is to be concrete-lined and will have capacity equivalent to circular section about 7 ft. 9 in. in diameter. It has been decided to filter the supply, but filters have not yet been designed. With some slight readjustment of water rates, net income will be sufficient to defray interest and sinking fund charges on new water supply, and additions to, and changes in, distribution system, all of which are now estimated to cost about $20,000,000. Unusual features of Act, under which work is being carried on, are discussed. Elaborate provisions made for regulation of flow in stream for benefit of lower mill owners.—*Almon L. Fales.*

Description of New Bedford Water System. STEPHEN H. TAYLOR. Jour. N. E. W. W. Assoc., **36**: 3, 370, Sept., 1922. Brief description of development of system. Present system in service since 1899 with old held in reserve. Water is taken from Little and Great Quittacas Ponds, located in Rochester, Lakeville, and Middleboro, about twelve miles north of City, through 6 feet masonry conduit. Combined storage capacity of two ponds is 5.5 billion gallons, and combined water sheds, about 10¾ square miles. Entire shore of both ponds and of part of tributaries is owned by city. Few buildings on these shores, which are kept free from pollution and almost entirely covered with good growth of wood. City owns 2,000 acres of land on water shed and is buying more as opportunity offers. Most of hard woods have been cut off and many thousand white, red, and Scotch pines planted, as well as some firs and hemlocks. Water, after passing through 8-mesh revolving screen, is pumped through steel force-main, 8 miles long, to High Hill Reservoir, which is divided into two separate units, total capacity being 68 million gallons. When full, elevation is such as to give from 14 to 90 pounds pressure on the system, average in business district being 65 pounds. Examinations of the steel pipe show considerable pitting, but indicate that it is still good for several years' service.

New 48-inch cast iron main is now being laid, which will make it possible to pump directly to distributing system in case of trouble with steel main, using reservoir as a balance. Cast iron main will eventually be carried to High Hill Reservoir. Wrought iron standpipe, 20 feet in diameter, and 75 feet high, has been erected and is connected with new force main at the summit, which is highest point in City. Pumping equipment and distribution system are described in detail. Average daily consumption last year about 71 gallons per capita, about 41 per cent accounted for by manufacturing meters, 40 per cent by domestic and commercial meters, and 19 per cent by fires, flushing, and all unmetered uses, and leakage. Total cost of works, to Dec. 1921, was $4,676,910.93. Description of experiments with Leadite and Lead-Hydro-Tite, as substitutes for lead for jointing cast iron pipe, which led to adoption of Leadite; and this has been used in practically all joints made since that time, with excellent results. Figuring cost of jute packing, labor, and lead, a 48-inch joint cost $18.06; whereas same items for leadite joint cost an average of $4.42. Braided jute packing has also been adopted for general use, as it has been found that, although this costs a little over twice as much per pound as plain dry jute, saving effected in labor and material more than offsets extra cost, and better joint is obtained because no loose ends of fiber mix with jointing material and reduce its efficiency. Paper is followed by interesting discussion.—*Almon L. Fales.*

The Use and Discard of Auxiliary Fire Protection from a Polluted Source. Caleb M. Saville. Jour. N. E. W. W. Assoc., **36:** 3, 392, Sept., 1922. Hartford, Conn., after trial period of 13 years in use of Double-Check Valve control between public water supply system and secondary source of water to be used for fire protection, has ordered complete severance of all such connections with its water system. Events leading to decision described. During past 10 years, leaky check valves have been reported on 61 occasions; of which, 34 were for outer check; 21, for inner check; and 6, for both checks. Most of secondary supplies were taken from Park River, which is badly polluted. Author presents a brief against use of cross-connections in case of polluted waters. Interesting discussion follows, in which both sides of question are presented. Conclusions of State Sanitary Engineers' Committee on Cross-Connections, By-Passes, and Emergency Intakes, on Public Water Supplies, are appended.—*Almon L. Fales.*

Some Court Decisions Incident to the Purchase of the Braintree Water Supply Company. Henry A. Symonds. Jour. N. E. W. W. Assoc., **36:** 3, 426, Sept., 1922. Court rulings in case appear to establish following points:—*First:* That a municipality, acting under the common form of charter rights relative to public utility, and having once taken formal vote to purchase, cannot subsequently rescind such vote. *Second:* That water cannot legally be drawn for municipal or other purposes from an underground supply having as source, or as part of its supply, a pond, or stream, in which no right of the municipality or company exists. *Third:* That selectmen of towns have regulatory supervision only, over streets; but rights of such a Board are not sufficient to prevent a public utility acting upon such streets in accordance with its charter

Fourth: Cash or other payments for stock are not necessary to legal organization of a public utility with Legislative charter.—*Almon L. Fales.*

Should the Water Department be Merged with Other Municipal Departments in its Management and Finances? George A. King. Jour. N. E. W. W. Assoc., **36**: 3, 434, Sept., 1922. Vital importance of Water Department to public health and comfort; need of keeping it out of politics; and importance of keepings its management in hands of man of experience and business ability. With Water Department united with other departments, danger that it will not receive attention its importance demands. As public utility, it should be maintained independently of general functions of municipal operations. Argument for separate management applies also to financing of the department. Revenues from Water Department should not be transferred to other departments. Author believes that system under which municipal light plants in Massachusetts are managed and financed, is best which has been devised for public utilities. Cities should adopt similar plan for water departments. It is not necessary to put them under State control to adopt this system, and its general adoption might forestall State control. Interesting discussion follows, in which strong sentiment appears against tendency prevailing in Massachusetts and elsewhere, to abolish Water Department and place it under Board of Public Works, simply making it a subordinate branch of city government without a superintendent. It was voted that a committee of Massachusetts members be appointed to consider advisability of united action with State authorities of Massachusetts on subject of merging Water Departments with other departments in management and finance, or either of them.—*Almon L. Fales.*

Why We Should Inspect Water Works Equipment. Thomas E. Lally Jour. N. E. W. W. Assoc., **36**: 3, 450, Sept., 1922. Causes of various faults and failures in water works systems detailed; many might have been prevented by adequate inspection equipment purchased. Description given of inspection for city of Boston, which is very rigid.—*Almon L. Fales.*

The Deep Core-Wall of the Wanaque Dam. Major Arthur H. Pratt. Jour. N. E. W. W. Assoc., **36**: 3, 457, Sept., 1922. This dam will impound waters of Wanaque River, one of tributaries of Passaic River, at point about 25 miles north of Newark. Capacity of reservoir will be between 11,000 and 27,000 million gallons, giving safe yield of 50 to 100 million gallons per day. Dam will be 1500 feet long, constructed of earth, with a core-wall extending to bed rock which outcrops on both hillsides, but, at bottom of valley, dips to about 100 feet below surface. Rock is gneiss, and overburden is water-bearing sand and gravel. Method adopted for constructing core-wall was to drive two walls of steel sheet piling across valley; excavate between them, using timber bracing; and fill with concrete. Detailed account is given of pile-driving methods, excavation, method of concreting core-wall, and progress made in construction. Paper is illustrated by drawings and photographs.—*Almon L. Fales.*

Boston High Pressure Fire System and General Problem of Special Fire Service. FRANK A. MCINNES. Jour. N. E. W. W. Assoc., **36**: 4,483, Dec. 1922. Boston high pressure fire system, put into service in February 1922, furnishes approximately two-thirds of measure of protection which completed system will afford; consists of two pumping stations, with four pumping units, 11.75 miles of mains, and 313 hydrants. Designed to deliver 12,000 gallons per minute with hydrant pressure of 250 pounds per square inch and pump pressure of 300 pounds per square inch. Suction mains connect with high service and low service distribution systems, and with emergency salt water supply. Details are given of pumping station distribution system and of signal system. General problem of special fire service is discussed, and testimony of number of fire chiefs quoted. Table is given embracing principal data of high pressure fire and auxilliary fire systems in United States and in Canada.—*A. L. Fales.*

High Pressure Fire Systems from the Underwriters' Viewpoint. G. W. BOOTH. Jour. N. E. W. W. Assoc., **36**: 4, 495. Dec., 1922. Losses most dreaded by fire insurance companies are those resulting from conflagrations. Conflagrations spread either by generation of an intense heat wave or by means of flying brands carried by wind. Former type of conflagration is of more importance in considering installation of High Pressure Fire Systems, because most of them occur in high-value, congested districts, and only in such districts is expense of separate fire main system warranted. Arguments in favor of high pressure fire system are summarized as follows: (1) Immense aggregations of buildings and contents in business districts of metropolitan cities: possibility of conflagrations involving tremendous losses and disastrous effects on business and civic growth, dictates most effective known means of preventing such catastrophes. (2) Large number of powerful streams can be concentrated on fire in much shorter time and with fewer men and less apparatus than with fire engines. (3) Protection of rest of the city will not be weakened to extent now necessary on third and fourth alarms from the district covered by system. (4) It will deliver its full capacity at any point in district covered and at any desired pressure and can sustain this pressure as long as wanted. (5) It eliminates confusion entailed in operation of large number of fire engines, tends to prevent misunderstanding of orders, and in every way simplifies operation. (6) It provides protection to congested value district even with general alarm fire under headway in another part of city, and forms effective barrier against fires starting outside district; while also affording most efficient means of checking fires in district which might otherwise involve a number of blocks. No definite information given as to extent of reduction in insurance rates following installation of high pressure fire systems. This matter is decided by insurance organization having local jurisdiction. Many insurance companies are willing to write greater lines on buildings after completion of a high pressure system. Interesting discussion of high pressure fire systems follows, including reasons for and against connecting automatic sprinklers with these systems.—*Almon L. Fales.*

Electric Pumping at Concord, N. H. P. R. SANDERS. Jour. N. E. W. W. Assoc., **36**: 4, 517, Dec., 1922. Two 2-million gallon Worthington triple

expansion pumps, handling average of 800,000 gallons per day were replaced by 8-inch single stage, double suction, volute pump having rated capacity of 3 million gallons per day, against net operating head of 120 feet, driven by an A. C. 100 H. P. General Electric Motor of squirrel-cage type operating at 1800 r.p.m. Electric power developed from Merrimack River is supplied by Concord Electric Co. at 1½¢ per K.W.H., or $6 per million gallons, based on yearly pumpage of 300 million gallons; all pumping to be done between 8 p.m. and 6 a.m., except in time of fire or other emergency. Cost of installation was $5,457.66, and cost of operation, approximately $13 per million gallons. By change to electric power, computed saving of 42.6 per cent in cost of pumping, and in addition, advantage of increased speed with which pump can be started in case of fire. In discussion, MR. EDMUND DUNN referred to the substitution of electric installation for steam, at Garfield, N. J., pumping 1,000 gallons per minute, 24 hours a day, which reduced cost of pumping from $1.46 to 92¢ per thousand cubic feet, cost of current being 1.17¢ per Kw.Hr. for minimum of 3,000 Kw.Hr. per month.—*Almon L. Fales.*

New Water Purification Plant at Norfolk, Virginia. WALTER H. TAYLOR. Eng. News-Record, **90**: 824–5, 1923. Plant installed to treat 12 m.g.d. and serve population of 120,000. Consists of weir aerators, coagulation basins and twelve 1 m.g.d. filters. Water is treated with alum and then aerated before sedimentation and filtration to remove CO_2 and odors.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

Accidents to Water Department Employees. ANON. Eng. News-Record, **90**: 750, 1923. At Detroit Water Dept. for year ending June 1, 1922, 248 accidents to employees were recorded, of which 205 were non-compensable. In the 43 compensable cases, $2459 compensation and $1374 hospital charges were paid. Fees for medical attention and services for the 248 cases were $2515. Of 91 automobile accidents with dept. cars, 13 were held to be the drivers' fault and 9, unavoidable.—*Frank Bachmann.*

Water Supply for a New City in India. ANON. Eng. News-Record, **90**: 841, 1923. Water supply for Delhi will be pumped from Jumna river to settling tanks. Water will then pass through filters of Paterson type. Plant will cost $2,300,000 and will furnish 30 gal. per capita for estimated 1955 population.—*Frank Bachmann.* (*Courtesy Chem. Abst.*)

New Publication. A new style of centrifugal pump, called a "series pump," is described in a catalog just issued by the De Laval Steam Turbine Company, Trenton, N. J. In this pump double suction impellers and volute diffusers are used, as in single stage centrifugal pumps. The connecting passages from stage to stage, however, are included in the pump case casting, as in the ordinary multistage pump. The advantages claimed are perfect hydraulic axial balance and high efficiency under varying loads, as is characteristic of the single stage pump. These series pumps are made with two or three stages. Where more than three stages are required, the use of two independent pumps operating in series and mounted on a single base plate is recommended in order to keep down the length of shaft between bearings.